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AGRICULTURAL SCIENCES

COMPARATIVE BIOMORPHOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF TOMATO CULTIVARS GROWN IN POLYCARBONATE GREENHOUSES IN THE ABSHERON ZONE OF THE REPUBLIC OF AZERBAIJAN

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Abstract

In 2023–2024, 42 tomato genotypes cultivated in cocopeat under greenhouse conditions at the "Vegetable Growing Research Institute" public legal entity were evaluated at the technical maturity stage based on certain morphological traits (fruit height, diameter, index, average fresh and dry weight per fruit) and biochemical parameters (dry matter, sugars, extractive substances, total acidity, sugar-to-acid ratio, nitrates). It was determined that in the studied tomato genotypes fruit height ranged from 32.97–64.29 mm, diameter 24.10–71.97 mm, index 0.76–1.50, average fresh and dry weight per fruit 7.41–135.67 g and 0.49–7.73 g, respectively; dry matter content 4.33–7.28%, sugars 1.0–4.28%, extractive substances (soluble in cell sap) 2.73–5.46%, total acidity 0.23–0.51%, sugar–acid ratio 1.96–13.38, nitrate content 56.0–202.9 mg/kg. The wide variation in these indicators among the studied tomato genotypes made it possible to select 10 samples differing in both appearance and biochemical composition, which can be used as valuable initial parental forms in future quality-oriented breeding. Such samples include genotypes 343, 394, 398, 401, 462, A-6 F_1, A-8 F_1, A-12 F_1, A-15 F_1, and A-17 F_1. In these samples, dry matter content was 5.65–7.28%, sugars 2.68–4.28%, extractive substances 4.06–5.46%, total acidity 0.23–0.38%, sugar–acid ratio 7.38–13.38, and nitrate content 56.0–185.6 mg/kg. Four of the selected F_1 hybrids also stood out for their lowest nitrate content (56.0–90.1 mg/kg), which is 3.33–5.36 times lower than the maximum permissible level (300 mg/kg) set by the Ministry of Health of the Republic of Azerbaijan for greenhouse-grown tomatoes. Therefore, these hybrids can undoubtedly serve as valuable initial donors in breeding programs aimed at producing environmentally safe products.

Keywords: tomato genotypes, biomorphological indicators, biochemical indicators, breeding, greenhouse.

Introduction. The cultivation of tomatoes in polycarbonate-covered greenhouses has specific characteristics related to creating an optimal microclimate and protecting the plants from diseases. During this cultivation, the optimal temperature for tomato growth should be **+22…+25°C during the day** and **+16…+18°C at night**. The temperature in the greenhouse should not be allowed to rise above **30°C**, as this may cause the anthers to become sterile and the flowers to fail to fertilize. In hot weather, the greenhouse should be ventilated to reduce the temperature; under these conditions, air circulation is not harmful to the plants [Balashov E.S., 2006]. In polycarbonate-covered greenhouses, vents are opened, and the upper part of the greenhouse can be whitened to protect against excessive heat. To ensure rapid evaporation of excess moisture, tomato plants should be irrigated during the first half of the day. A. Orlov (2021) demonstrated that both high and low temperatures negatively affect tomato plants under greenhouse conditions. When the temperature decreases to 13–15°C, flower buds do not open and fertilized ovaries drop, while at 10°C plant growth ceases. At 5°C, flowers and fruits are destroyed. Light frosts are lethal for tomato plants. Similarly, when the temperature rises above 32°C, pollen grains do not germinate, photosynthesis is weakened, and fruits become pale. Under low light levels, tomato plants elongate, stems thin, leaves become small, and the flower cluster forms above the 10th leaf. The critical light intensity is considered to be 2000–3000 lx, at which point the consumption of plastic substances in respiration exceeds the production from photosynthesis. For normal formation of generative organs, the light intensity should not be below 4000–6000 lx.

N.M. Pus and N.A. Snezkov (2021) found that when cultivating tomatoes on inert substrates in winter greenhouses using innovative agricultural methods, the delivery of nutrients to the substrates via drip irrigation promotes the proper development of both the plants' root systems and the plants themselves. They reported that under such cultivation, tomato fruits contained 4.53–4.87% dry matter, 1.35–1.47% sugars, 11.20–15.99 mg/100 g of ascorbic acid, and 7.60–15.56 mg/kg of nitrates. In another study, tomato plants grown under greenhouse conditions exhibited variations in main stem length and leaf number, and a strong correlation was established between these indicators and plant productivity (r = 0.83–0.89) [E.V. Sokolova et al., 2020].

According to the literature, the application of humic fertilizers during the cultivation of vegetables, particularly tomatoes, in covered soil promotes the production of high-quality, environmentally safe products. Koryagin et al. [Yu.V. Koryagin et al., 2020] reported that under such treatment, tomato fruits contained 5.9–7.6% dry matter, 2.0–2.6% sugars, 25.2–26.8 mg/100 g of ascorbic acid, and 0.72–0.75% total acidity. Nitrate content – a toxic substance – ranged from 90 to 103 mg/kg, representing a 6.4–18.2% reduction compared with the control. Overall, depending on the stage of development, tomato fruits typically contain 4.5–15.0% dry matter, 1.0–4.5% sugars, 0.2–0.9% organic acids, and 19–55 mg/100 g of vitamin C (on a fresh weight basis) [Allahverdiyev E.I. et al., 2020; Musin A.K. et al., 2020; Anisimov A.M., 2021]. The content of toxic substances – nitrates – in tomato fruits can vary widely depending on the microclimatic conditions in the greenhouse, as well as on irrigation and fertilization regimes and light intensity. In our studies, nitrate levels in tomato fruits never exceeded the permissible limit set by the Ministry of Health of the Republic of Azerbaijan for this greenhouse-grown vegetable (300 mg/kg), with the maximum value recorded at 201.9 mg/kg [Yusifov M.A., Agazade F.N., 2003; Agayev F.N. et al., 2023; Agayev F.N. et al., 2024]. It is known that **nitrates themselves are not harmful to the human body**. The danger arises only from their reduced form **nitrites.** Nitrites readily enter condensation reactions with **secondary amines and amides** present in food, forming **nitrosamines.** Currently, there are over **300 nitrosamines** known to have **carcinogenic effects**. On the other hand, it should be noted that **nitrates are essential substances for the human body**. Their effect on the human organism is **dual in nature** positive, by enhancing the body's defense functions, and negative, by contributing to the development of **oncological diseases** and **methemoglobinemia** [Litvinov S.S. et al., 2014].

Thus, summarizing the above, it can be concluded that under Absheron conditions, tomato genotypes in greenhouse environments have not been sufficiently studied from biomorphological and biochemical perspectives, and highly productive and high-quality varieties and hybrids suitable for greenhouse conditions have not been developed. Our research is conducted specifically to address this gap, making it highly relevant for modern vegetable production in Azerbaijan.

The purpose of the study. The main purpose of the research was to comparatively evaluate tomato genotypes grown in cocovit under greenhouse conditions in Absheron based on their morphological and biochemical characteristics, and to select valuable parental forms for future quality-based breeding.

Object and methodology of the study. The object of the study comprised 42 tomato genotypes. Plant care and biometric measurements were carried out according to generally accepted methodology [Litvinov S.S., 2011]. Irrigation and mineral nutrition were applied using the drip method [Ezaev A.K., Shibzukhov Z.S., 2017].

The total sugar content in the fruits was determined using an RA-130 refractometer (Korea), the content of extractive substances was measured with an RX-5000 CX extractor (ATAGO, Japan), nitrates were measured using a Nitratometer (SOEKS), and the total acidity and dry matter content were determined according to the methodology of A.I. Yermakov [1987].

The **fruit index** was determined using the following formula:

$$J = \frac{H}{D},$$

Here **J** — fruit index, **H** — fruit height, mm; **D** — fruit diameter, mm.

The **statistical analysis of the research results** was carried out according to **S.S. Litvinova (2011)**.

Results and Discussion of the Study. The fruits of **42 tomato genotypes** (2 regional varieties, 1 promising variety, 2 selections, 14 pure lines, and 23 F_1 hybrids) grown in **cocovit under greenhouse conditions** were evaluated at the **technical maturity stage** for certain **morphological** (fruit height, diameter, index, average fresh and dry weight per fruit) and **biochemical** (dry matter, sugars, extractive substances, total acidity, sugar-to-acid ratio, nitrates) characteristics (Tables 1 and 2). It was determined that in the studied samples, **fruit height** ranged from **32.97 to 64.29 mm, diameter** from **24.10 to 71.97 mm,** and the **fruit index** from **0.76 to 1.50.** The **average fresh and dry weight per fruit** were **7.41–153.71g** and **0.49–8.22g**, respectively. The **dry matter content** in the fruits ranged from **4.33 to 7.28%**, **sugar content** from **1.0 to 4.28%**, **extractive substances** from **2.73 to 5.46%**, **total acidity** (calculated as malic and citric acid) from **0.23 to 0.51%**, the **sugar-to-acid ratio** from **1.96 to 13.38**, and **nitrate content** from **56.0 to 202.9 mg/kg**.

The wide variation of morphological and biochemical traits among genotypes allows for the selection of samples that differ according to the reliability level (LSD_{05}). Statistical analysis of the obtained results [S.S. Litvinov, 2011] showed that the fruit height and diameter were 48.49 ± 5.02 mm and 57.0 ± 6.04 mm, respectively, with LSD_{05} for these traits being 9.99 mm and 12.02 mm. The fruits differ in height as follows at a 95% confidence level: 398 (64.29 mm), A-17 (32.97 mm), and A-15 (36.08 mm). In terms of diameter, the fruits differ as follows: 394 (71.66 mm), 396 (71.97 mm), A-15 (24.10 mm), and A-17 (33.81 mm). Regarding the fruit index, only A-15 (1.50) differs. The remaining samples fall within the confidence interval. Deviations from the confidence interval for fruit moisture and dry mass are observed in a

larger number of genotypes. Such genotypes include 393 (120.62 and 6.15 g), 394 (130.19 and 8.01 g), 396 (152.71 and 8.22 g), 462 (135.67 and 7.73 g), and A-18 (128.05 and 7.15 g). The remaining samples have fruit moisture and dry mass values within the confidence interval. An interesting point is that all genotypes differing in the upper confidence interval are large-fruited. However, it should be noted that there are also samples differing in the lower confidence interval. These include A-15 (7.41 and 0.49 g), A-17 (13.12 and 0.96 g), and A-7 (50.27 and 2.55 g).

It should be noted that the majority of the studied tomato genotypes were flat-oval in shape (34 genotypes – 0.76–0.90), only one genotype was elongated (1.50), and seven genotypes were relatively elongated-round in shape (0.91–0.98).

Table 1.

Comparative evaluation of the fruits of tomato genotypes grown in cocopeat under greenhouse conditions according to some biomorphological parameters (average for 2023–2024)

№	Catalog sample of the VGRI	Names of the genotypes	Fruit height, mm	Fruit diameter, mm	Fruit index	Average moisture content per fruit, g	Average dry mass per fruit, g
1	86	**Banovsha, registered variety, standard**	51,13	63,67	0,80	120,45	5,80
2	138	Shalala, registered variety, standard	42,91	52,61	0,82	63,14	3,88
3	140	**Pure line**	50,11	61,44	0,82	94,90	4,41
4	283	**Pure line**	47,77	60,92	0,78	101,85	5,56
5	285	**Pure line**	46,27	55,77	0,83	87,82	5,48
6	296	**Pure line**	48,33	60,30	0,81	93,41	5,70
7	306	**Pure line**	49,40	59,20	0,83	93,45	5,05
8	307	**Pure line**	43,75	51,20	0,86	60,94	3,28
9	321	**Pure line**	45,26	56,74	0,80	68,13	3,77
10	343	**Pure line**	48,64	64,24	0,76	74,45	4,45
11	356	**Pure line**	48,14	62,32	0,77	101,21	5,70
12	393	**Pure line**	53,66	65,06	0,83	120,62	6,15
13	394	Sample selected from the variety Atlas	55,63	71,66	0,78	130,19	8,01
14	395	**Pure line** (New variety)	49,38	56,88	0,87	86,52	4,61
15	396	**Pure line**	64,29	71,97	0,89	152,71	8,22
16	398	Sample selected from the variety First Ladu	47,19	53,57	0,88	62,10	3,62
17	401	**Pure line**	46,37	52,62	0,83	62,43	3,67
18	415	**Pure line**	45,75	58,17	0,79	62,89	3,29
19	417	**Pure line**	43,70	56,74	0,80	74,45	3,93
20	462	Mulmuctap F_1	54,22	65,63	0,83	135,67	7,73
21	A-1	(43x420) F_1	49,05	63,10	0,78	109,70	5,34
22	A-2	(495x391) F_1	50,64	56,45	0,90	78,61	4,11
23	A-3	(436x415) F_1	52,41	58,94	0,89	92,14	4,88
24	A-5	(306x285) F_1	42,30	50,85	0,83	59,10	3,36
25	A-6	(475x468) F_1	49,78	53,54	0,93	72,92	4,18
26	A-7	(138x283) F_1	40,86	47,97	0,85	50,27	2,55
27	A-8	(375x436) F_1	52,66	56,45	0,93	81,12	4,93
28	A-9	(198x306) F_1	49,81	57,31	0,87	87,85	4,88
29	A-10	(198x307) F_1	45,16	49,99	0,90	59,36	3,08
30	A-12	(420x415) F_1	48,50	60,55	0,80	93,81	5,30
31	A-14	(306x283) F_1	47,62	54,63	0,87	77,11	3,97
32	A-15	(351x447) F_1	36,08	24,10	1,50	7,41	0,49
33	A-17	(584x351) F_1	32,97	33,81	0,98	13,12	0,96

34	A-18	(487x395) F_1	53,41	66,09	0,81	128,05	7,15
35	A-20	(468x420) F_1	52,32	54,77	0,96	81,61	3,94
36	A-24	(487x321) F_1	54,94	64,95	0,85	102,38	5,76
37	A-25	(487x143) F_1	49,74	53,44	0,93	78,90	3,97
38	A-26	(375x425) F_1	47,44	59,85	0,90	75,86	3,97
39	A-27	(307x283) F_1	45,82	50,13	0,91	60,28	3,04
40	A-28	(307x306) F_1	50,76	55,95	0,91	77,66	4,03
41	A-29	(468x438) F_1	54,89	61,70	0,89	108,96	4,72
42	A-30	(391x143) F_1	47,63	58,78	0,81	86,13	4,16
Range of variation			32,97-64,29	24,10-71,97	0,76-1,50	7,41-152,71	0,49-8,22 q
$\bar{X}\pm S_{\bar{x}}$			48,49±5,02	57,0±6,04	0,89±0,11	83,80±16,21	4,55±0,87
LSD $_{05}$			9,99 mm	12,02 mm	0,22	32,26 q	1,73 q

The results of the statistical analysis of biochemical parameters (Table 2) showed that, among the studied genotypes, the mean values were as follows: dry matter 5.48 ± 0.44%, sugars 2.84 ± 0.26%, extractive substances 4.37 ± 0.42%, total acidity 0.37 ± 0.03%, sugar-acid ratio 8.15 ± 0.98, and nitrate content 119.14 ± 20.61 mg/kg. The LSD_{05} values for the studied indicators were 0.88, 0.52, 0.84, 0.06 %, 1.95, and 41.01 mg/kg, respectively. At the upper 95 % confidence level, genotypes A-15 (6.63 %) and A-17 (7.28 %) differed significantly from the other genotypes, whereas at the lower confidence level, genotype A-29 (4.33 %) was distinct.

The dry matter content of the remaining 39 genotypes was within the confidence interval (4.65–6.15%). For sugar content, genotypes 394 (3.43%), A-24 (3.47%), A-12 (3.60%), A-8 (3.62%), A-15 (3.70%), and A-17 (4.28%) were distinguished at the upper 95% confidence level, whereas genotypes A-7 (1.0%), 296 (2.0%), and 401 (2.17%) differed at the lower confidence level. Thus, in the remaining 39 genotypes, the dry matter content was within the confidence interval (4.65–6.15%). For sugar content, at the upper confidence level, genotypes 394 (3.43%), A-24 (3.47%), A-12 (3.60%), A-8 (3.62%), A-15 (3.70%), and A-17 (4.28%) were distinguished, whereas at the lower confidence level, genotypes A-7 (1.0%), 296 (2.0%), and 401 (2.17%) differed. Regarding the content of extractive substances, at the upper confidence level, only genotype A-17 (5.46%) was distinguished, whereas at the lower confidence level, genotype A-7 (2.73%) differed. In the remaining genotypes, sugar and extractive contents were within the confidence intervals.

In terms of total acidity, the number of samples differing at the upper confidence level was relatively high. These included genotypes 86 (0.51%), 138 (0.45%), 283 (0.50%), 285 (0.46%), 296 (0.47%), A-1 (0.45%), A-7 (0.51%), A-10 (0.44%), A-14 (0.47%), A-27 (0.48%), and A-28 (0.45%). At the lower confidence level (below 0.31%), the differing genotypes included A-2 (0.28%), 417 (0.30%), 398 (0.23%), 395 (0.28%), 394 (0.25%), and 307 (0.30%).

Regarding the sugar-to-acid ratio, at the upper confidence level (above 10.10), the following genotypes differed: 394 (13.19), 385 (11.43), 398 (11.65), A-6 (10.38), A-8 (11.68), A-12 (11.25), A-15 (11.94), A-17 (13.38), and A-24 (10.52). At the lower confidence level (below 6.20), the distinct genotypes were A-27 (5.83), A-10 (5.75), A-7 (1.96), 296 (4.26), 285 (5.44), 283 (5.06), 140 (5.75), 138 (5.78), and 86 (4.51).

Table 2.

Comparative evaluation of the fruits of tomato genotypes grown in cocopeat under greenhouse conditions due to some biochemical indicators (average for 2023–2024)

№	Catalog sample of the VGRI	Names of the geno-types	Dry matter, %	Sugars, %	Extractive sub-stances, %	Total acidity, %	Sugars / Acidity	Nitrates, mg/kg
1	86	**Banovsha, registered variety, standard**	5,25	2,30	4,34	0,51	4,51	80,3
2	138	Shalala, registered variety, standard	6,15	2,60	4,60	0,45	5,78	97,4
3	140	**Pure line**	4,65	2,30	3,79	0,40	5,75	80,6
4	283	**Pure line**	5,56	2,53	4,53	0,50	5,06	105,5
5	285	**Pure line**	5,43	2,50	4,48	0,46	5,44	107,5
6	296	**Pure line**	6,10	2,0	4,05	0,47	4,26	110,8
7	306	**Pure line**	5,40	2,50	4,26	0,33	7,58	154,5
8	307	**Pure line**	5,33	2,57	4,13	0,30	9,57	198,1
9	321	**Pure line**	5,53	2,50	4,17	0,33	7,58	140,9
10	343	**Pure line**	5,33	2,73	4,36	0,37	7,38	152,3
11	356	**Pure line**	5,63	2,50	4,57	0,31	8,07	105,3
12	393	**Pure line**	5,10	2,50	4,15	0,25	10,0	134,9
13	394	Sample se-lected from the variety Atlas	5,99	3,43	4,70	0,26	13,19	185,6
14	395	**Pure line** (New vari-ety)	5,33	3,20	4,53	0,28	11,43	175,9
15	396	**Pure line**	5,38	2,85	4,72	0,36	7,92	136,3
16	398	Sample se-lected from the variety First Ladu	5,89	2,68	4,06	0,23	11,65	111,3
17	401	**Pure line**	5,88	2,17	4,99	0,33	8,79	107,3
18	415	**Pure line**	5,23	3,40	4,79	0,39	8,72	81,8
19	417	**Pure line**	5,28	2,50	4,15	0,30	7,23	140,9
20	462	Mulmuctap F_1	5,70	3,30	4,90	0,38	8,68	160,9
21	A-1	(43x420) F_1	5,20	3,20	4,91	0,45	7,11	154,3
22	A-2	(495x391) F_1	5,23	2,78	4,21	0,28	9,93	152,5
23	A-3	(436x415) F_1	5,30	3,30	4,43	0,38	8,68	81,0
24	A-5	(306x285) F_1	5,68	2,80	4,09	0,42	6,67	75,8
25	A-6	(475x468) F_1	5,73	3,32	4,69	0,32	10,38	83,0
26	A-7	(138x283) F_1	5,08	1,0	2,73	0,51	1,96	76,0
27	A-8	(375x436) F_1	6.08	3,62	4,90	0,31	11,68	31,1
28	A-9	(198x306) F_1	5,15	2,37	4,06	0,36	6,58	71,5
29	A-10	(198x307) F_1	5,18	2,53	3,87	0,44	5,75	61,6

30	A-12	(420x415) F_1	5,65	3,60	5,0	0,32	11,25	109,0
31	A-14	(306x283) F_1	5,15	2,03	4,31	0,47	6,45	119,0
32	A-15	(351x447) F_1	6,63	3,70	4,99	0,31	11,94	56,0
33	A-17	(584x351) F_1	7,28	4,28	5,46	0,32	11,38	74,2
34	A-18	(487x395) F_1	5,58	3,0	4,34	0,33	9,09	176,0
35	A-20	(468x420) F_1	4,83	2,80	4,06	0,36	7,78	104,6
36	A-24	(487x321) F_1	5,63	3,47	4,57	0,33	10,52	89,8
37	A-25	(487x143) F_1	5,03	3,0	4,26	0,38	7,90	104,6
38	A-26	(375x425) F_1	5,23	3,25	4,51	0,34	9,56	202,9
39	A-27	(307x283) F_1	5,05	2,80	4,05	0,48	5,83	110,4
40	A-28	(307x306) F_1	5,18	2,70	4,15	0,45	6,44	110,8
41	A-29	(468x438) F_1	4,33	2,50	3,77	0,38	6,58	110,5
42	A-30	(391x143) F_1	4,83	2,73	3,38	0,34	8,03	117,5
Range of variation			4,33-7,28	1,0-4,28	2,73-5,46	0,23-0,51	1,96-13,38	56,0-13,38
$\bar{X}\pm S_{\bar{x}}$			5,48±0,44 %	2,84±0,26	4,37±0,42	0,37±0,03	8,15±0,98	119.14±20,61
LSD_{05}			0,88 %	0,52 %	0,84 %	0,06 %	1,95	41,01 mq/kq

It is known that the sugar-to-acid ratio (or sugar-acid index) in tomato fruits should be at least 7 for optimal quality, especially when processing tomatoes for juice and paste. This ratio is an important indicator determining the taste quality of the fruits [Pikaleva A.S., 2018; Machulkina V.A. et al., 2014; Pavlov L.V. et al., 2011]. According to Pikaleva, as the sugar-to-acid index decreases, the quality of the tomato declines, and the taste of the resulting juice or paste deteriorates. In the study by Machulkina V.A. et al., the sugar-to-acid index ranged from 8.8 to 12.2, and they concluded that this ratio depends more on the biological characteristics of the genotype than on other factors. Nevertheless, the value of this ratio is also influenced by mineral nutrition and the storage conditions of the tomatoes.

In our previous studies, we noted that the content of toxic substances – nitrates−in tomato fruits depends on the biological characteristics of the genotypes, soil and climatic conditions, the level of mineral nutrition, the degree of ripeness, and other factors [Agayev F.N. et al., 2023; 2024; Allahverdiyev E.I. et al., 2020; Yusifov M.A., Agazade F.N., 2003]. The results of the present study showed that the nitrate content in tomato fruits averaged 119.14 ± 20.61 mg/kg, with a CV (Coefficient of Variation at 5% significance level) of 41.01 mg/kg. At the 95% confidence level, the genotypes with the highest nitrate content (above 160.15 mg/kg) were A-18 (176.0), A-26 (202.9), 307 (198.1), 394 (185.6), 395 (175.9), and 462 (160.9 mg/kg), whereas those with the lowest nitrate content (below 78.13 mg/kg) were A-5 (75.8), A-7 (76.0), A-9 (71.5), A-10 (61.6), A-17 (74.2), and A-15 (56.0 mg/kg).

As a result of the study, 10 tomato genotypes were selected based on a complex of biochemical characteristics and recommended for future selection according to quality (Table 3). In these selected samples, the dry matter content ranged from 5.65 to 7.28%, the sugar content from 2.68 to 4.28%, the extractives from 4.06 to 5.46%, total acidity from 0.23 to 0.38 %, the sugar-to-acid ratio from 7.38 to 13.38, and the nitrate content from 56.0 to 185.6 mg/kg.

It should be noted that, as in our previous studies, in the present study the content of toxic substances – nitrates in tomato fruits did not exceed the permissible limit established by the Ministry of Health of the Republic of Azerbaijan for greenhouse-grown tomatoes (300 mg/kg) and was 1.48–5.36 times lower than this limit.

Table 3.

Tomato genotypes grown in cocopeat under greenhouse conditions, selected based on biochemical composition and recommended for breeding according to quality (average for 2023–2024)

№	Catalog sample of the VGRI	Names of the genotypes	Dry matter, %	Sugars, %	Extractive sub-stances, %	Total acidity, %	Sugars / Acidity	Nitrates, mg/kg
1	343	**Pure line**	5,98	2,73	4,36	0,37	7,38	152,3
2	394	Sample selected from the variety Atlas	5,99	3,43	4,70	0,26	13,19	185,6
3	398	Sample selected from the variety First Ladu	5,89	2,68	4,06	0,23	11,65	111,3
4	401	**Pure line**	5,88	3,17	4,99	0,33	8,79	107,3
5	462	Mulmuctap F_1	5,70	3,30	4,90	0,38	8,68	160,9
6	A-6	(375x468)F_1	5,73	3,32	4,69	0,32	10,38	83,0
7	A-8	(375x436)F_1	6,08	3,62	4,90	0,36	11,68	90,1
8	A-12	(420x415)F_1	5,65	3,60	5,0	0,32	11.25	109,0
9	A-15	(351x447)F_1	6,63	3,70	4,99	0,31	11,94	56,0
10	A-17	(584x351)F_1	7,28	4,28	5,46	0,32	13,38	74,2
Range of variation			5,65-7,28	2,68-4,28	4,06-5,46	0,23-0,38	7,38-13,38	56,0-185,6

Conclusion. Under Absheron conditions, the morphological and biochemical characteristics in the fruits of tomato genotypes cultivated on cocopeat in a greenhouse vary over a wide range. The mean values of fruit height, diameter, and moisture and dry mass were 48.49 ± 5.02 mm, 57.09 ± 6.04 mm, 83.80 ± 16.21g, and 4.55 ± 0.87g, respectively.

The mean values of the biochemical parameters were as follows: dry matter 5.48 ± 0.44 %; 0.88%, sugars 2.84 ± 0.26%; 0.52%, extractive substances 4.37 ± 0.42%; 0.84%, total acidity 0.37 ± 0.03%; 0.06%, sugar-acid ratio 8.15 ± 0.98 1.95, and nitrates 119.14 ± 20.61 mg/kg; 41.01 mg/kg, respectively.

As a result of the study, ten cultivars − 343, 394, 398, 401, 462, A-6, A-8, A-12, A-15, and A-17 were selected based on a set of biochemical parameters and are used as valuable donors for selection aimed at high quality.

The genotypes A-15, A-17, A-6, and A-8 among the studied hybrids exhibit extremely low nitrate levels (56.0–90.1 mg/kg, 3.33–5.36 times below the permissible limit), making them valuable parental forms for breeding aimed at producing environmentally safe products.

Among the studied hybrids, the genotypes A-15, A-17, A-6, and A-8 exhibit extremely low nitrate levels (56.0–90.1 mg/kg, 3.33–5.36 times below the permissible limit), making them valuable parental forms for breeding aimed at producing environmentally safe products.

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ART STUDIES

SUZHOU IN THE SOUNDSCAPE: URBAN SPACE TRANSFORMATION AND THE PERSISTENCE OF TRADITIONAL MUSIC

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Abstract

This paper adopts the theoretical perspective of "soundscape" to examine the preservation and adaptation of Suzhou's traditional music amidst urban spatial transformations. It first analyzes the symbiotic relationship between sound and space in the classical period, where Suzhou's gardens, waterway neighborhoods, and community spaces interacted with Kunqu opera, Pingtan storytelling, and Jiangnan silk and bamboo music, revealing how music functioned as an auditory vehicle for cultural practice and local identity. Next, it explores the systematic rupture of traditional soundscapes during modernization, caused by the reshaping of urban fabric, the replacement of functional spaces, and the intrusion of modern noise, as well as the reconstitution of music through mediatized dissemination. Furthermore, it discusses how contemporary traditional music achieves resilient survival and meaningful transformation within new spatial orders through strategies such as attachment to cultural landmarks, integration into tourist-consumer spaces, utilization of digital media, and cross-domain experimentation. Finally, the paper reflects on the challenges facing soundscape preservation, including the erosion of spatial belonging, functional transformation, and intergenerational divides, proposing future pathways that shift from "static preservation" to "soundscape ecological cultivation" and employ technological mediation to create experiential connections. This paper argues that the preservation of Suzhou's traditional music is fundamentally a dynamic negotiation of the socio-spatial relationships of sound, and its future depends on the ability to reconstruct meaningful auditory connections between music, people, and place within the contemporary city.

Keywords: Soundscape, Suzhou, Traditional Music, Urban Space, Spatial Transformation, Cultural Preservation, Pingtan, Kunqu, opera.

Introduction:

Modern urban studies have long been dominated by visually oriented narratives, with skylines, architectural forms, and spatial layouts constituting the core dimensions for understanding cities. However, cities are not merely "viewed" landscapes but also "heard" soundscapes. Sound, as a transient yet profound medium carrying cultural memories and emotional structures, intertwines with specific spaces to shape a place's unique identity and perceptual experience. Suzhou, this historic city renowned for its classical gardens and waterway layout, also weaves a rich and intricate soundscape into its cultural fabric—Peking opera's plucked strings, Kunqu opera's meandering melodies, and the fresh, lingering tones of Jiangnan silk and bamboo music once formed the vibrant background sounds of canal markets, garden halls, and alleyways. These sounds do not exist in isolation; together with white-walled houses, black-tiled roofs, and small bridges over flowing water, they constitute a complete historical and cultural ecosystem—a "hearing Suzhou." This study introduces the theoretical perspective of "soundscape," aiming to move beyond analyzing traditional music as an isolated art form and instead explore its dynamic process as spatialized sound practice and cultural heritage, seeking how it persists and adapts amid the intense modernization of cities.

The concept of "soundscape" goes beyond the realm of physical acoustics, emphasizing how sound is heard, interpreted, and shaped by society and culture. It refers to a sense of place in an auditory sense, which is the shared auditory environment and cultural identity formed by specific groups in historical layers. For Suzhou, its traditional music is the core component of this sound landscape. They were once closely coupled with specific spatial types - the intricate and profound nature of Kunqu opera and the intricate and profound nature of gardens complement each other; The street narrative of Pingtan complements the noisy atmosphere of teahouses and bookstores; The clear and bright beauty of silk and bamboo music blends seamlessly with the festive rituals of folk communities. This symbiotic relationship between "sound space" makes music not only entertainment, but also the giver of spatial meaning and organizer of social relationships. However, the wave of urbanization that has swept across China in recent decades has profoundly reconstructed the urban texture of Suzhou. River dredging and road widening have changed the auditory skeleton of cities, while commercial development and changes in residential patterns have eroded traditional sound carrying spaces. The diffusion of modern noise has reshaped the overall auditory background.

In this context, the core question of this study is highlighted: how should traditional music in Suzhou cope with the systematic deconstruction of the existing "sound space" coupling relationship? What strategies do they use to embed the new urban spatial order, and what changes have occurred in their cultural functions and meanings? Answering these questions is not only related to the protection technology of intangible cultural heritage, but also to how we understand how an auditory based cultural memory and local identity are possible in the process of modernization. This article

will draw a map of the changes in Suzhou's sound landscape through historical literature review, field observation, and in-depth interviews, and track the trajectory and tension of traditional music on this map.

1.Historical Layer: The Coexistence of Traditional Music and Classical Space Sound in Suzhou

To understand the contemporary situation of traditional music in Suzhou, we first need to return to its nurturing and prosperous classical urban pattern. During the Ming and Qing dynasties, Suzhou, as the economic and cultural center of Jiangnan, presented a highly organic and functionally mixed urban space: private gardens were scattered throughout the streets and alleys of the city, a dense network of waterways connected the shops, temples, and residences, while tea houses, taverns, clubs, and bookstores were embellished at the intersection of water and land. This unique spatial structure is not just a passive container for sound generation, but actively participates in the formation, dissemination, and reception of musical styles, weaving together a rich and meaningful sound landscape. Kunqu opera, Pingtan, and Jiangnan silk and bamboo, the three most representative Suzhou sounds, have formed profound and subtle symbiotic relationships with gardens, water alleys, streets, and temple communities, respectively.

Gardens can be regarded as the spiritual container and auditory temple of Kunqu art. These "mountains and forests within reach" carefully constructed by literati pursue the creation of infinite mountain and water imagery and worldly feelings in a limited space. Its spatial aesthetics emphasize twists and turns, profundity, concealment, and borrowing scenery. Correspondingly, the auditory environment in gardens is highly controlled, introverted, and exquisite. The "Shuimoqiang" of Kunqu Opera, with its melodic twists and turns, elegant and refined lyrics, and delicate and beautiful instrumental accompaniment, forms a wonderful formal isomorphism with the winding corridors, hidden flowers and trees, and tranquil pool water in the garden. In the elegant gathering of the garden owner, Kunqu opera performed in the hall, water pavilion or outdoor stage, its sound waves are gently reflected and absorbed between the pink walls, flower windows, and lake stones, creating a special reverberation effect that is both clear and hazy, close to the ear and distant. This acoustic characteristic enhances the aesthetic character of Kunqu Opera, which is characterized by elegance, refinement, elegance, and warmth. More importantly, as a private realm for retreat, socializing, and contemplation, gardens provide Kunqu Opera with a closed auditory space that breaks away from the hustle and bustle of the city and focuses on expressing inner emotions and literary appreciation. Here, music is not only entertainment, but also an acoustic emblem of the cultural identity and elegant taste of the literati class, and a perfect realization of spatial poetry in the auditory dimension.

In sharp contrast to the privacy and elegance of gardens, the flowing and open public auditory network formed by water alleys and street markets is the fertile ground for Suzhou Pingtan to take root and sprout. The double chessboard pattern of "parallel water and land, adjacent rivers and streets" in Suzhou allows sound to freely flow, intersect and spread along the river and streets. Pingtan, especially Suzhou Pinghua and Tanci, is essentially a popular narrative art. The docks, bridges, tea houses, and professional bookstores have become its most important performance venues. These spaces are crowded with people, frequently exchanging information, and filled with the noise and vitality of life. Pingtan artists need to use clear and loud voices, rhythmic strings, and vivid stories to capture the audience in an open or semi open environment. Therefore, the music and narrative style of Pingtan are relatively straightforward and lively, with strong narrative power, and can flexibly absorb current language and common topics. The tea drinkers sip and listen, occasionally cheering and interacting, and this viewing relationship is loose, casual, and highly socialized. The sound of Pingtan mixed with the oars on the water, the cries of vendors, and the noise of the street market, forming the classic background sound of Suzhou's urban public life. It is not only for entertainment and leisure, but also an important channel for the common people to obtain information, form social discussions, and share moral concepts. Its voice itself carries the pulse and breath of the city.

At the broader level of community life and folk festivals, Jiangnan silk and bamboo play a core role in uniting communities and creating an atmosphere. Silk and bamboo music is often used in folk ceremonies such as weddings, funerals, temple fairs, and divine birthdays, as well as in self entertainment activities of literati gatherings and folk music societies. Its performance space is flexible and varied, ranging from private halls, ancestral halls, squares in front of temples, to temporary streets and empty spaces. Silk and bamboo music has a fresh and soft tone, a bright and smooth rhythm, and a small and flexible arrangement. It is very suitable for playing in non professional, crowded open or semi open spaces, creating a festive or solemn atmosphere without overwhelming the audience. It does not require listeners to sit quietly and appreciate like Kunqu, nor does it rely on sustained narrative appeal like Pingtan. Instead, it serves as an "environmental music" that participates in the process of collective activities. For example, in the procession of temple fairs, silk and bamboo music is a sound that guides rhythm and creates atmosphere; At community gatherings, it serves as a harmonious accompaniment to neighborhood socialization. Through joint performance and listening, silk and bamboo music strengthens regional cultural identity and the bond within the community, and its sound becomes an audible symbol of collective memory and emotional community in the community.

2.Fracture and Reconstruction: The Transformation of Sound Space in the Modernization Process

Since the mid-20th century, especially since the reform and opening up, the wave of urbanization and modernization sweeping across China has fundamentally reshaped the urban texture, social structure, and daily life rhythm of Suzhou. This dramatic transformation guided by economic development and spatial efficiency has exerted a systematic and structural impact on the sound landscape formed based on classical

patterns. The traditional symbiotic relationship between "sound space" has encountered an unprecedented rupture, while at the same time, new sound orders and spatial logic are constantly emerging, collectively forming the complex and tense auditory landscape of contemporary Suzhou. The process of fracture and reconstruction is not a simple linear substitution, but a dynamic result of the interweaving of multi-level and multi-dimensional forces.

2.1 The drastic changes in physical space and the disintegration of auditory context

The material reconstruction of urban space is the most direct and fundamental driving force for the transformation of soundscapes. Firstly, the evolution of water and land transportation networks has fundamentally shaken the classical framework of Suzhou's soundscapes. In order to meet the demand for motor vehicle traffic, a large number of rivers have been buried or transformed into underground channels covered by expressways, causing the "water lanes" that used to be natural channels for sound and the core stage of life to shrink sharply. Iconic sounds such as oars, hawking along the river, and dialogue by the window have gradually declined. Instead, the continuous traffic noise on the city's main roads - the roar of engines, the friction of tires, and the honking of horns - form a new and overwhelming urban auditory background. This transformation is not only a replacement of sound types, but also a shift in auditory focus: from linear water lane soundscapes with human scale and narrative richness, to machine scale, homogeneous and non personalized road noise fields.

Secondly, the substitution and specialization of urban functional spaces have eroded the specific places where traditional music relies on for survival. The mixed functional layout of residential, commercial, and entertainment in classical Suzhou has been replaced by the functional zoning concept in modern urban planning. A large number of traditional tea house bookstores have either disappeared due to the renovation of old cities or become unsustainable due to changes in consumption patterns. Their functions as daily performances of Pingtan and core nodes for social interaction in the market have seriously deteriorated. Gardens have completely transformed from the private living spaces of literati to tourist attractions and cultural relics protection units for the public. The noise of tourists, the loudspeaker explanations of tour guides, and the standardized playing of background music have collectively transformed the auditory environment of the garden. Although Kunqu opera performances in the park have been preserved, most of them have become regular and fixed-point tourism exhibition projects, and their original elegant style privacy, improvisation, and immersion have been largely dissolved. Music is detached from the 'background' that permeates daily life and placed in the 'front stage' where it is viewed and consumed.

Furthermore, the profound transformation of residential patterns has removed the soil of community-based music activities. The shift from "neighborhood units" that live by the water and are connected by streets and alleys to modern residential models dominated by high-rise residential buildings and enclosed communities has weakened the informal, face-to-face communication opportunities and public life among community members due to physical spatial isolation. The community rituals (such as weddings, funerals, and festivals) that Jiangnan silk and bamboo rely on for survival still exist, but their organizational forms and spatial carriers have changed, and many traditional rituals have been simplified or transferred to commercial venues. The spontaneous and non-profit music club activity space within the community is being squeezed, leading to a loose social network for the inheritance and daily practice of silk and bamboo music.

2.2 The mixture of sound order and the marginalization of music culture

Along with the dramatic changes in physical space, the overall sound order of the city has also undergone a profound process of hybridization. The modern city itself is a huge noise generator, intertwined with the impact of construction sites, electronic music in commercial centers, and the buzzing sound of countless air conditioning units, as well as the remaining sound of water alleys and occasional traditional music, forming a fragmented auditory environment lacking dominant cultural logic. In this environment, the sound of traditional music is no longer a natural and dominant acoustic marker in a specific space, but has become a "cultural fragment" that needs to be deliberately searched for or accidentally encountered.

As a result, traditional music presents two significant marginalization tendencies in practice - "museum oriented" and "stage oriented". Museumization "refers to the detachment of music from the living context and its inclusion as a precious" heritage "in institutional protection and exhibition spaces, such as Suzhou Opera Museum and Pingtan Museum. Here, music is carefully preserved, studied, and performed, but its organic connection with its original social functions and daily life is severed, mainly serving the purposes of education, research, and cultural display; Stageization "refers to the transfer of music from streets and alleys, tea houses and halls to professional modern theaters, music halls, and television and radio programs. This transformation has undoubtedly improved the technical quality and viewing experience of performances, but at the same time solidified the binary opposition between actors and audiences, weakening the interactivity, casualness, and sense of community participation commonly seen in traditional performances. Whether it is museum oriented or stage oriented, it means that music has transformed from a participatory way of life to an ornamental cultural consumer product.

2.3 The Rise of New Sound Spaces and the Reshaping of Auditory Experience

However, rupture is not the end of the story. The modernization process has not only dissolved the traditional sound space, but also spawned a series of new sound carrying and propagation spaces, providing alternative and sometimes paradoxical paths for the survival of traditional music.

The most significant is undoubtedly the specialized cultural performance space. Modern venues such as Suzhou Kunqu Opera House and Suzhou Cultural and Art Center provide high-quality and standardized

exhibition platforms for Kunqu Opera and Pingtan with their advanced acoustic design, lighting and stage design, and comfortable viewing environment. These spaces have given traditional art a modern "high art" positioning, attracting new, especially young, educated audiences. On the other hand, this highly regulated "black box" style space has also domesticated the performance forms of traditional music, making it more inclined to present complete, classic, and frozen versions rather than flexible and varied folk states.

The more revolutionary impact is the comprehensive expansion of the media space. From radio and television to today's Internet and mobile new media, the spread of sound completely gets rid of the constraints of geographical space. Pingtan selection and Kunqu opera singing can reach potential enthusiasts worldwide through online audio, short video platforms, and live streaming. This' de spatialization 'dissemination greatly expands the audience base of traditional music, especially attracting non local and younger groups. But media logic has also reshaped the presentation and reception habits of music: fragmented dissemination, visual packaging, interactive feedback, making auditory experience increasingly shift from immersion to browsing, from focus to accompaniment.

In addition, a mixed cultural tourism space has become a new habitat for traditional voices. After the renovation, historical districts such as Pingjiang Road and Shantang Street have introduced a large number of tea houses, cafes, and boutique hotels with Pingtan performances. The real-life performances of "Peony Pavilion" and "Six Records of Floating Life" launched by the garden at night transform classical spaces into immersive theaters. In these scenarios, traditional music is carefully "embedded" into a designed nostalgic or romantic atmosphere, becoming a cultural added value that attracts tourists and enhances the consumer experience. The function of music here is not so much about artistic inheritance as it is about creating "local customs" and constructing sound decorations for consumer scenarios.

2.4 The tension of existence: strategies and practices of traditional music in contemporary space

Against the backdrop of the modern rupture of the traditional symbiotic relationship between sound and space, the survival of traditional music in Suzhou is not simply a disappearance or return, but a tense and creative spatial practice. Various actors - from institutional institutions and market forces to practitioners and communities - use diverse strategies to attempt to weave ancient voices back into the fabric of contemporary cities. These practices reveal the resilience, compromise, and innovation exhibited by traditional music in adapting to new spatial logic.

Firstly, it is the solidification of "iconic" cultural spaces under institutional protection. Represented by Suzhou Kunqu Opera House, Suzhou Pingtan Museum in China, and a group of bookstores recognized as "inheritance bases", these spaces have become the most stable "strongholds" of traditional music in contemporary cities through government support and professional operation. They undertake the functions of inheriting, showcasing, researching, and educating classic plays, ensuring the standardization and purity of the artistic essence. However, this solidification is often accompanied by some kind of "isolation". In these highly institutionalized venues, music is carefully nurtured, but it also creates a distance from the daily flow of urban life, primarily serving specific audiences. At a specific time of cultural consumption, its social function shrinks from a universal "life background" to a specialized "cultural exhibition".

Secondly, it is the embedding of tourism and consumption space driven by the market. In historical districts such as Pingjiang Road and Shantang Street, as well as classical gardens such as Liuyuan and Wangshi Garden, Pingtan and Kunqu performances have become indispensable sound symbols in shaping the experience of "Su style life". This kind of embedding is a double-edged sword: on the one hand, it provides considerable economic support and exposure to traditional music, directly reaching domestic and foreign tourists in a "live" form, and realizing the economic value transformation of culture; On the other hand, music can easily be simplified as replicable "background music" or decorative elements, and the duration, selection, and style of its performances are often adjusted to cater to tourists' fragmented time and shallow experiences. The integrity and depth of artistic exploration give way to atmosphere creation and consumer satisfaction. The relationship between music and space has shifted from internal symbiosis to external grafting.

Outside of official and market channels, some folk music societies, independent artists, and young creators are exploring more penetrative spatial strategies. For example, some Jiangnan silk and bamboo clubs insist on regularly rehearsing in community activity centers and park pavilions, maintaining a miniature, non utilitarian voice community; Some Pingtan artists have attempted to hold "micro performances" in modern cafes, art galleries, and even subway stations, unexpectedly breaking traditional sounds into the gaps of urban life and creating auditory "strangeness" surprises; More crossover musicians have incorporated materials from Kunqu Shuimoqiang or Pingtan Sanxian into electronic, rock, or theater music, creatively transforming them for completely different audiences in contemporary cultural spaces such as Livehouse and art and culture festivals. These practices are often small-scale but more flexible and experimental, attempting to break the traditional music's preconceived "classical" framework and explore new possibilities for its connection with contemporary emotions and aesthetics.

In addition, digital technology is building an increasingly important "virtual reality" hybrid soundscape. High definition audio and video files, VR landscape Kunqu opera experience, location-based sound map APP, etc. enable traditional music to break free from the limitations of physical space and be saved, reorganized, and disseminated in the form of data streams. This' virtual existence 'not only restores or simulates historical soundscapes, but also creates new listening experiences and interactive modes, opening up an immersive path for the younger generation to access heritage. However, the experience of digital intermediaries is ultimately highly personalized and contex-

tualized, and whether and how it can contribute to offline real community interaction and spatial perception remains an open question.

3.The dilemma and potential for the survival of soundscapes in the future

The survival practice of traditional music in Suzhou in contemporary times has demonstrated a resilient adaptability, but behind it lies profound tension and difficulties. The core contradiction lies in the displacement of space causing a drift in meaning. When music migrates from its native life context to tourist theaters, modern concert halls, or digital screens, its essence shifts from a participatory social behavior to a cultural symbol that is appreciated. This transformation weakens the organic connection between music and local daily life, and its collective memory, community identity, and ritual functions are subsequently weakened. Secondly, the intergenerational gap in auditory culture is becoming increasingly evident. Under the shaping of globalization and digital media, the auditory habits of the younger generation are becoming more fragmented, electronic, and transnational, and the aesthetic system, narrative rhythm, and emotional expression of traditional music are facing "decoding" obstacles. In addition, the paradox of protection and development persists: standardized and staged "protection" may drain its vitality, while overly commercialized "innovation" may dissolve its cultural core.

Looking towards the future, the reshaping of Suzhou's sound landscape may need to go beyond the static maintenance of the "heritage" itself and shift towards the dynamic construction of a new type of "sound space community" relationship. The path may lie in: firstly, promoting a shift in thinking from "physical space protection" to "soundscape ecological creation". Consciously integrating sound design into urban planning and community renewal, such as setting up "sound landmarks" in historic districts and planning small immersive performances in public spaces, allowing traditional music to re penetrate the urban fabric in a light and daily way. Secondly, explore creative transformation under the mediation of technology. By utilizing immersive audio, AR, and other technologies, interactive "historical soundscapes" can be constructed in physical or virtual spaces, allowing listeners to shuttle between ancient and modern auditory experiences and establish new cultural connections empowered by technology. Ultimately, the key to survival may not lie in reproducing a frozen past, but in the ability to use sound as a link to build a perceptible, participatory, and sustainable bridge between contemporary life experiences and local cultural memories.

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ECONOMIC SCIENCES

АМЕРИКА- СТРАНА ИММИГРАНТОВ

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AMERICA IS A COUNTRY OF IMMIGRANTS

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Аннотация

В последнее время одной из глобальных проблем стала иммиграция населения всех стран. Причины, такие как военные конфликты, политические преследования, природные катаклизмы и одной из основных причин — это экономическая нестабильность, Люди эмигрируют в страны с сильной экономикой и с стабильной социальной политикой в отношении эмигрантов. Иммиграция - это процесс движения группы или потока населения одной страны в другую. Этот процесс ведет с собой как положительные, так и отрицательные моменты, что сказывается на экономике, обществе и религиозной стороне принимающий страны. Поэтому должен быть выработан специальный механизм для принятия эмигрантов, который бы регулировал все сферы их проживания в принимающем государстве соответственно с законодательством и порядком принимающей страны. На самом деле эти процессы представляют собой не только экономическую, но и междисциплинарную концепцию, касающуюся всех аспектов нашей жизни. В этом контексте целью данного исследования является изучение концепции процесса иммиграции как глобальную проблему мирового сообщества в рамках устойчивого развития. Это исследование вносит вклад в исследования и литературу в области миграционных процессов в мире. Чрезвычайную важность движение эмигрантов оказывает на экономики как принимающей, так и страны-донор и для всех стран мира необходимо изучить более глубоко.

Abstract

In recent years, immigration has become one of the global challenges facing countries around the world. Causes such as armed conflicts, political persecution, natural disasters, and one of the main factors—economic instability—drive people to migrate. People emigrate to countries with strong economies and stable social policies toward immigrants. Immigration is the process of movement of a group or flow of population from one country to another. This process brings both positive and negative effects, influencing the economy, society, and the religious aspects of the host country. Therefore, a special mechanism should be developed for receiving immigrants, which would regulate all aspects of their residence in the host state in accordance with the legislation and order of the receiving country. In fact, these processes represent not only an economic phenomenon but also an interdisciplinary concept affecting all aspects of our lives. In this context, the aim of this study is to examine the concept of the immigration process as a global problem of the world community within the framework of sustainable development. This research contributes to existing studies and literature in the field of global migration processes. The movement of migrants is of critical importance to the economies of both host and donor countries, and for all countries worldwide it is necessary to study this issue in greater depth.

Ключевые слова: иммиграция, эмигранты, иммиграционная политика, иммиграционный поток, Америка и американцы.

Keywords: immigration, emigrants, immigration policy, immigration flow, America and Americans.

Иммиграция сегодня — это предмет горячих споров и дискуссий в правительственных кабинетах практически во всех странах мира. Особенно остро стоит этот вопрос в Соединенных Штатах Америки. Иммиграция и миграция в целом, как уже было сказано ранее, сложное и многогранное явление, которое может иметь, порой неоднозначные последствия. То, что иммиграция оказывает воздействие на рынок труда и экономику страны в целом, это неоспоримый факт. Однако вектор этого воздействия для каждой отдельной страны свой. Влияние - иммиграции носит противоречивый характер — имеются, несомненно, позитивные стороны, этого процесса, есть и отрицательные.

Иммиграция - горячо оспариваемая проблема в Соединенных Штатах. Как и в других странах, в США имеются две диаметрально противоположные точки зрения относительно воздействия иммигрантов на экономику страны. При этом каждая сторона, ссылаясь на результаты проведенного исследования, доказывает свою правоту. Причем такие дебаты распространены не только среди представителей власти, но и в научных сообществах страны.

В процессе исследования, проанализировав значительный объем данных официальных статистических служб США, а также результаты выборочных обследований, мы заключили, что иммиграция для Соединенных Штатов, в основном; оказывает позитивное влияние.

Воздействие иммиграции на принимающую страну можно определить, оценив ее влияние на следующие основные аспекты:

- влияние иммиграции на численность и структуру населения;
- влияние на рынок рабочей силы;
- влияние иммиграции на экономику в целом.

Влияние иммиграции на рынок труда. Проблема воздействия иммиграции на рынок рабочей силы для США не новая. На протяжении всей своей истории эта проблема не утрачивала актуальность даже в прошлые столетия, когда в иммиграции все видели основной фактор экономического роста и всячески поощряли ее. В наше время подход к иммиграции изменился. Сейчас США переживают новую волну иммиграции, которая отличается от предыдущих волн и в количественном, и в качественном отношении. По данным министерства труда США, в 2008 г. численность иностранных рабочих составила 24,1 млн. чел., что составляет 15,7% в общей численности: всех занятых в экономике. По сравнению с 2006 г., этот показатель увеличился на 0,4%.

В конце XX - начале XXI вв., был проведен ряд исследований американскими учеными. Для объективности, приведем пример выводов, которые сделали- американские демографы, имеющие диаметрально- противоположные взгляды, относительно влияния иммигрантов на рассматриваемую проблему. Дж. Боржас (Borjas), исследовав доходы низкоквалифицированных работников в 1980-2000 гг., сделал вывод о том, что из-за иммиграции доходы в этой категории работников снизились на 8,9% при том, что общее снижение доходов составило 11%. B5 то же время ряд других исследователей выявили более скромное влияние иммиграции на заработную плату. F.Rivera-Batiz отмечает, что, хотя? иммиграция и увеличила заметно с конца 80-х годов XX в. число работников с низким уровнем образования, ее влияние на уровень заработной платы минимально. Наиболее основательно к данной проблематике подошли экономисты Р. Фридберг (Friedberg) и Д. Хант (Hunt). Применив математические методы анализа динамики заработной платы в период с 1980-1995 гг., они пришли к выводу, что увеличение на 10% доли иммигрантов в общей численности трудовых ресурсов приведет, максимум, к падению уровня заработной платы на 1%. На уровень оплаты труда оказывает влияние множество других факторов, в числе которых уровень образования и квалификация работника, сложившаяся экономическая конъюнктура и др. В этом как раз и заключается сложность оценки влияния иммиграции на рынок труда.

Уровень образования является одним из основных факторов, оказывающим влияние на доходы. Это утверждение справедливо, как для коренных американцев, так и для иммигрантов. Сводные результаты анализа уровня заработной платы среди коренного населения и иммигрантов, и ее дифференциации, в зависимости от уровня образования,

Вторым, немаловажным, вопросом, является степень влияния иммигрантов на уровень безработицы в стране. Из курса экономической теории известно, что уровень безработицы отражает сложившуюся экономическую ситуацию в стране: Ярким примером служит финансовый кризис, который мы наблюдаем сегодня. Никто не будет спорить, что резкий всплеск безработицы стал следствием не иммиграции, а ухудшения состояния самой экономики. Финансовый кризис, в первую очередь, ударил по иммигрантам, как менее защищенной категории работников. Уровень безработицы среди иммигрантов, впервые за последнее десятилетие, превысил уровень среди коренных американцев. За первый квартал 2009 г. уровень безработицы среди иммигрантов составил 9,7%, в то время как среди коренных работников значение этого показателя составляло 8,6%. В третьем квартале 2007 г. уровень безработицы среди иммигрантов составлял 4,1%, для коренных - 4,8%. Таким образом, за полтора года, вследствие финансового кризиса, показатели безработицы увеличились более чем в 2 раза. Однако, как видно из приведенных данных, уровень безработицы среди иммигрантов вырос на 5,6%, тогда как для коренных американцев только на 3,8%. Уровень безработицы среди иммигрантов, не имеющих диплома об окончании средней школы, увеличился в I квартале 2009 г. на 9,9% по сравнению с III кварталом 2007 г. до 14,7% Для коренных американцев из этой же группы уровень безработицы вырос за этот же период на 7,9%.

Нельзя обойти стороной и прямое влияние иммиграции на рынок труда. Это воздействие детерминируется из иммиграционной политики США. Одним из основных пунктов в получении статуса постоянного жителя США являются преференции для инвесторов, вкладывающих средства в депрессивные районы или в сельское хозяйство страны. Одним из основных условий является создание не менее 10 рабочих мест для граждан и постоянных жителей США. За последний период число таких иммигрантов возросло со 129 в 2004 г. до 809 человек в 2007 г. Таким образом, в 2007 г., помимо инвестиций, иммигранты, как минимум, создали 8090 новых рабочих мест для американцев. Закон устанавливает только минимальное значение в 10 мест. К сожалению, полных данных о том, сколько рабочих мест было создано на самом деле, нет. Можно с уверенностью сказать, что реальная цифра намного больше.

Исследование влияния трудовой иммиграции на среднее значение недельного дохода местных работников показало очень слабую связь. Для расчета были взяты данные о численности иммигрантов и уровне дохода за период с 1992 по 2007 гг. включительно. Значение полученного коэффициента корреляции составило 0,35, коэффициента детерминации - 0,12. Таким образом, только 12% вариации среднего недельного дохода объясняется вариацией численности трудовых иммигрантов.

Однако, положительный знак коэффициента корреляции говорит о том, что иммиграция не является фактором снижения заработной платы местного населения в целом.

Рассмотрим вопрос, насколько иммигранты возвращают, через налоги, различные социальные блага. Ответ на этот вопрос будет зависеть в первую очередь от возраста и образования иммигранта на момент прибытия в страну. Возраст иммигранта — основной детерминант воздействия на экономику страны. Иммигранты трудоспособного возраста, продавая свой труд, будут полноценным источником налоговых и иных обязательных отчислений в бюджеты. Иммигранты более ранних возрастов первое время- действительно будут потребителями социальных услуг, однако этот период временный, поскольку после вступления в трудоспособный возраст они станут полноценными налогоплательщиками, в то время как иммигранты-старших возрастных групп, т.е. пенсионного возраста, естественно, будут основными потребителями социальных услуг в долгосрочной перспективе. Однако и здесь возможны, случаи, когда иммигранты, получающие пенсии, продолжают заниматься полноценной трудовой деятельностью, тем самым частично компенсируя затраты государства на их содержание.

Исследуя возрастную структуру постоянных иммигрантов, можно оценить положительное влияние. Иммигранты в возрастной группе от 60 лет составляли 8,6% всего потока-в 2007 г., доли иммигрантов в возрасте до 16 лет - 16,7%, таким образом, 74,7% иммигрантов, получивший статус постоянного жителя США находятся-в трудоспособном возрасте.

Следующим детерминантом влияния иммиграции на экономику является время, а точнее период времени, который исследуют. Большинство противников иммиграции при исследовании влияния тех или иных ее аспектов рассматривают их в краткосрочной перспективе. На наш взгляд, это неправильно. Последствия иммиграции необходимо рассматривать на макроуровне и только за достаточнодлинный период времени. Это опять же связано с самой природой такого явления, как миграция. Исследовать влияние за один или даже два года невозможно. Если семья иммигранта многодетна и все дети дошкольного или школьного возраста, социальные выплаты будут значительными, что отразится в так называемом пассиве баланса. Этимиданными и оперируют противники! иммиграции, ссылаясь на цифры. Но пройдет некоторое время, эти дети вступят в трудоспособный возраст и станут полноценными гражданами страны, вносящими свою- частичку в экономику США. Однако это уже никто не будет подсчитывать, поскольку они будут считаться постоянными жителями. Таким образом, в краткосрочной перспективе, иммиграция действительно может оказать отрицательное воздействие на экономические показатели, но уже в среднесрочной и долгосрочной перспективе это отрицательное воздействие в полном объеме перекроется положительными результатами.

Рассматриваемое выше влияние иммиграции на экономику США, больше относилось к косвенному. В арсенале современной иммиграционной системы США, есть один пункт, при выполнении которого, экономика страны в любом случае оказывается в выигрыше от иммигрантов. Наравне с тем, что мы отметили выше, иммигранты создают новые рабочие места; иммиграция, основанная на преференциях для инвесторов, предполагает помимо создания 10 новых рабочих мест, также инвестирование в экономику страны не менее 500 тыс. долл. США. Законом установлены две категории иммигрантов-инвесторов. В первой категории потенциальному иммигранту необходимо инвестировать не менее 500 тыс. долл., во второй не менее 1 млн. долл. США. Как было сказано в первой главе нашего исследования, разница только в количественных ограничениях - квоте. Для тех, кто инвестирует от 500 тыс. до 1 млн. долл. квота составляет 3 тыс. виз и 7 тыс. виз при инвестировании свыше 1 млн. долл. США.

В 2007 г., как и во всех других годах, квота ни разу не была превышена. Но, тем не менее, положительные результаты имеются. В 2007 г. такими преференциями воспользовались. 809 человек. К сожалению, нет данных относительно того, сколько было инвесторов в каждой из категорий. Поэтому, чтобы не получить завышенные данные, условно приняли в расчет, что все эти иммигранты инвестировали по 500 тыс. долл. США, т.е. чистые инвестиции в экономику США от данного вида иммиграции составили 40,5 млн. долл. США. Конечно, по сравнению с ВВП страны, это ничтожно маленькая цифра, однако мы произвели расчет по минимальным критериям. Во-вторых, необходимо учитывать косвенное влияние, а именно эффект от этого инвестирования в будущем: расширение производства, увеличение числа рабочих мест, увеличение налоговых отчислений.

Положительный эффект от иммиграции наблюдается в повышении производительности труда. Создавая определенную конкуренцию, иммигранты вынуждают коренных американцев, особенно с низкой квалификацией, работать более продуктивно, а также повышать свою квалификацию с целью сохранения своего рабочего места и дальнейшего карьерного роста.

Программа по выдаче виз H-1B, по которой зарубежные специалисты приезжают работать в США, была введена Законом об иммиграции в 1990 г., когда после резкого скачка в развитии технологий в страну ежегодно приезжали почти 200 тыс. квалифицированных специалистов. В 2005 г. правительство уменьшило квоту в 2 раза. Ряд корпораций неоднократно высказались за увеличение лимита рабочих виз. Заснятие ограничений особенно активно ратуют IT-компании, которые остро нуждаются в талантливых сотрудниках-иностранцах. Некоторые члены палаты представителей конгресса США, лоббирующие интересы компаний «Силиконовой долины», также выступают за увеличение квот, либо за их полную отмену.

Основными странами выезда ученых и высококвалифицированных рабочих являются: Индия -

600 тыс. человек, Мексика — 500 тыс. человек, а также Филиппины, Китай, Канада, Германия и Великобритания.

Денежные переводы иммигрантов - еще один из спорных вопросов при оценивании влияния иммиграции на экономику страны. Противники иммиграции, в качестве аргументов в свою пользу, активно используют данные о размерах денежных переводов иммигрантами в свои страны для манипулирования сознанием простых граждан. Этот показатель важен, поскольку может быть отслежен статистическими службами. Однако, как показывает практика, точных данных ни одна служба предоставить не может. По данным Всемирного Банка, в 2006 г. объем денежных переводов из США составил 42,2 млрд. долл. Некоторые исследователи считают, что эта цифра на порядок выше. В США, как и в каждой стране, можно найти приверженцев широко распространенного мнения, что вывоз или перевод заработанных денег оказывает исключительно негативный эффект для экономики страны. На наш взгляд, намного важнее знать законность этого дохода, а также были ли с него уплачены налоги в соответствии с законодательством страны. Возможно, экономика страны получила гораздо больше выгоды от трудовой деятельности иммигранта. К тому же, значительную часть своего заработка иммигрант тратит на текущее потребление в стране пребывания, тем самым создавая дополнительный спрос на товары и услуги.

На основании всего сказанного, можно сделать вывод, что иммиграция, в целом, оказывает позитивное влияние на экономику. Результаты эмпирических исследований показывают необоснованность целого ряда обвинений, выдвинутых противниками иммиграции. В иммиграции, конечно, есть и отрицательный момент: в частности, ее влияние на рынок труда низкоквалифицированных рабочих, а также проблема незаконных иммигрантов. Но при этом иммигранты способствуют экономическому росту страны, создавая предприятия, занимая вакантные рабочие места, производя все больше товаров и услуг, это ведет к увеличению налоговых отчислений.

Они формируют дополнительный спрос на товары и услуги, приносят свой опыт и квалификацию, производят товары, ранее недоступные или только импортируемые, тем самым снижая их стоимость. Особо ценен вклад иммигрантов в высокотехнологические отрасли экономики, а также в научную сферу деятельности. Вместе с коренными американцами, иммигранты вместе способствуют экономическому росту и благосостоянию всей нации.

В заключении, хотелось бы отметить, что, даже не вдаваясь в глубокий анализ различных экономических показателей, по результатам исследования влияния иммиграции на численность и структуру США, можно сделать вывод о том, что иммиграции является основным геополитическим фактором существования США, как сверх державы, поскольку, как нами было доказано в первой части этой главы, иммиграция является основным фактором роста численности населения.

Во второй половине XX в. в иммиграционной политике США произошли изменения, которые ознаменовали новый этап в развитии- взаимоотношений иммигрантов с принимающей их страной. Либерализация- политики в отношении, иммигрантов с 1965 г. решила ряд острых проблем, накопившихся вовремя реструкуционной иммиграционной политики. Вместе с тем, по мере развития и укрепления внешнеэкономических связей между странами, а также связанного с этими процессами прибытия новых иммигрантов, снова вынудили американских законодателей? искать новые путирешения проблем; связанных с иммиграцией. Самое сложное, что предстояло сделать, это направить иммиграционный поток в то русло, которое служило бы на благо процветания страны и всей нации.

Спустя всего110 лет после принятия Закона об иммиграции 1965 г., стало ясно; что новая иммиграционная система не справляется с возложенными на нее обязанностями. В 1978 г. Конгрессом была создана специальная комиссия, в задачи которой входила разработка рекомендаций по реформированию иммиграционной политики. Новая иммиграционная система должна была решить ряд важных задач. А именно:

- разработка механизма, упрощающего процедуру получения американского гражданства для родственников граждан США;
- создание условий, которые обеспечивали бы привлечение в страну высококвалифицированных рабочих, ученых и деятелей искусства;
- развитие экономически отсталых регионов страны, а также создание новых рабочих мест для местных жителей США посредством внедрения нового канала иммиграции - бизнес-иммиграция;
- выработка мер, направленных на увеличение этнического разнообразия иммиграционного потока;
- разработка инструментов, направленных на поддержку лиц, которым необходимо временное убежище и которые по тем или иным причинам не могут в данный момент времени проживать в своей родной стране.

Основой новой иммиграционной системы США стал Закон об иммиграции 1990 г., подписанный президентом США Дж. Бушем 29 ноября 1990 г. Он установил общую квоту для выходцев из других стран, получающих иммиграционный статус, которая составила в 1992-1994 финансовых годах - 700 тыс., а начиная с 1995 финансового года, 675 тыс. человек. Число иммигрантов из любой страны не должно превышать 7% от всех прибывших.

Иммигранты, которые могут претендовать на получение статуса беженца, но которые не могут въехать в США в. этом статусе, по причине исчерпания ежегодной квоты, могут воспользоваться особым режимом въезда. Они могут въехать в статусе «пароль» - условное разрешение на въезд с возможностью приобретения иммиграционного статуса в будущем.

США также могут предоставить убежище лицу, которое вынуждено покинуть свою страну по причине того, что там оно подвергалось или будет

подвергаться преследованию Количественные квоты для1 этой категории иммигрантов не установлены.

Главной особенностью нового иммиграционного закона является появление категории лиц, получающих статус временной защиты. Он предоставляется жителям тех стран, в которых наблюдается крайне нестабильная обстановка, чаще всего в результате вооруженных конфликтов, природных стихий, в том случае, если эти обстоятельства могут привести к существенным, но временным ухудшениям условий жизни. Список стран и также общее число таких иммигрантов определяется правительством США. Срок действия статуса временной защиты может варьироваться от 6 до 18 месяцев. Лица, обладающие данным статусом, не могут быть депортированы, и они не могут покидать территорию США, а также претендовать на получение статуса постоянного жителя США. Главной задачей правительства США, разработавшего столь обширное разнообразие не иммиграционных виз, было упорядочивание оснований; по которым: иммигрант может въехать- в. страну. Принятие новых законов чаще всего сопровождается ужесточением условий к потенциальным иммигрантам, а также к тем, кто уже получил статус постоянного жителя США. Но основой иммиграционной системы в настоящее время по-прежнему остается Иммиграционный закон от 1990 г.

Проведенное нами исследование позволяет сделать следующие выводы:

1. На протяжении всего времени существования США иммиграция являлась сильной стороной национальной идентичности. Сегодня в Соединенных Штатах каждый восьмой житель является или являлся иммигрантом, т.е. был рожден за пределами США. Это самый высокий уровень иммигрантов в общей численности населения страны со времен 20-х годов XX века.

2. Иммиграция оказывает определяющее влияние на демографическую ситуацию США. Ежегодно численность населения страны увеличивается на 1%. Иммигранты обеспечивают более половины годового прироста численности населения. Иммигранты имеют большее число детей, по сравнению с тем числом, которое бы у них было, если бы они остались в своей родной стране. Это справедливо в отношении почти всех этнических групп. Уровень образования женщин-иммигранток является одним из основных факторов, определяющим число детей. Женщины с более низким уровнем образования склонны заводить большее число детей, нежели те, кто имеет более высокий уровень образования.

3. Иммиграция в целом оказывает положительное влияние на рынок труда. Иммигранты выполняют многие общественно необходимые работы в тех секторах, которые остро испытывают структурную нехватку рабочей силы. В первую очередь это касается низкооплачиваемых, непрестижных, тяжелых и опасных работ, на которые неохотно идут местные жители. Широкое использование дешевого низкоквалифицированного труда иностранцев служит важным фактором функционирования целого ряда традиционных- отраслей, таких как аграрный сектор; доля иммигрантов в котором составляет 70% от общего числа занятых. Нигде вклад иммигрантов не был более очевиден, как в высокотехнологичных и наукоемких секторах.

Современный финансовый кризис по-разному сказался на американском рынке труда. Больше всего от него пострадали именно иммигранты, уровень безработицы среди иммигрантов превышает аналогичный показатель среди местного населения, особенно эта диспропорция наблюдается в низкоквалифицированном сегмента рынка труда.

4. Иммиграция является одним из основополагающих факторов роста экономики США. Производя и потребляя национальную продукцию, выплачивая налоги и социальные взносы, делая сбережения, иммигранты увеличивают ВВП США. Вклад иммигрантов в производство ВВП был особенно существен в послевоенные годы.

5. Основой современной иммиграционной политики является Закон 1990 г., который с некоторыми дополнениями и поправками действует и сегодня общая квота установлена в 675 тыс. человек в год, начиная с 1995 г., причем число иммигрантов из любой страны не должно превышать 7% от всех прибывших.

7. В результате проведенного исследования, нами были разработаны концептуальные положения по совершенствованию миграционной политики с учетом накопленного опыта, в области привлечения иммигрантов

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INTERNATIONAL GREEN FINANCE STANDARDS (GREEN BONDS, ICMA, EU TAXONOMY)

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Abstract

In the context of global climate change and increasing environmental risks, green finance is becoming a key tool for sustainable development of the global economy. In this context, international standards that ensure transparency, comparability, and trust in financial instruments supporting environmentally oriented projects are particularly important. This article examines the key international green finance standards, including Green Bonds, the ICMA Green Bond Principles, and the EU Taxonomy. It analyzes their essence, objectives, structure, and role in developing a unified approach to classifying "green" economic activities. Particular attention is paid to the importance of these standards for the development of sustainable financial markets, minimizing the risks of "greenwashing," and attracting private capital to environmental projects.

Keywords: green finance, green bonds, Green Bonds, ICMA, Green Bond Principles, EU Taxonomy, sustainable development, ESG, climate investments, greenwashing.

1. Introduction.

The modern global economy is developing in the face of growing environmental and climate challenges, including global warming, rising greenhouse gas emissions, and the degradation of natural ecosystems. In response to these challenges, the concept of sustainable development is actively being developed at the international level, integrating environmental, social, and economic factors into financial and investment decision-making[1]. The key instrument for implementing this concept is the green finance system, aimed at mobilizing financial resources to support projects that contribute to the mitigation of climate change and adaptation to it[2]. In recent years, the green financial instruments market has demonstrated steady growth, with green bonds occupying a special place in its structure, widely used by public and private issuers[3]. However, the rapid development of the green bond market has revealed the problem of the lack of uniform criteria for classifying projects as environmentally sustainable, which increases the risk of unfair use of funds and the spread of greenwashing practices.[4]In this regard, the role of international standards, ensuring transparency, comparability, and reliability of information for investors and regulators, is increasing.

Of key importance among such standards are the ICMA Green Bond Principles, which are a voluntary market-based regulatory mechanism, and the European Union Taxonomy, which is based on a normatively established system for classifying environmentally sustainable economic activities[5]. Their use helps build trust in the green finance market and increases its investment attractiveness. The purpose of this article is to analyze international green finance standards and assess their role in the development of sustainable financial markets. This objective involves examining international experience, conducting a comparative analysis of key standards, and drawing conclusions that have practical implications for the development of national green finance systems.

2. Methodological aspects of the research.

The methodological basis of the research was a combination of general scientific and specialized methods for analyzing economic processes in the field of sustainable finance. The work employed methods of analysis and synthesis, induction and deduction, and a systems approach, allowing for the examination of green finance as an element of the global financial architecture[6]. A comparative method was used to compare the ICMA Green Bond Principles and the European Union Taxonomy to identify their functional and institutional differences. Economic and statistical methods were applied to analyze the dynamics of the global green bond market and the structure of financed projects.

An institutional approach allowed us to assess the role of international organizations and regulators in shaping green finance standards and mitigating the risks of greenwashing. The study's information base included official reports from international financial institutions, EU regulations, and scientific publications by international researchers.

3. International experience of the research.

The research shows that green finance has been most developed in the European Union, where a comprehensive regulatory framework for sustainable finance has been established. The central element of this system is the EU Taxonomy, which establishes uniform criteria for the environmental sustainability of economic activity[7].

In the US and Asia-Pacific, green finance is being developed primarily through voluntary standards, in particular the ICMA Green Bond Principles, which are widely adopted by issuers and institutional investors[8].

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[1]Sachs JD The Age of Sustainable Development. New York: Columbia University Press, 2015.
[2]OECD. Developing Sustainable Finance Definitions and Taxonomies, Paris, 2021.
[3]Climate Bonds Initiative. Global Green Bond Market Summary, London, 2023.
[4]World Bank. Green Bond Impact Report, Washington, DC, 2023.
[5]European Commission. EU Taxonomy for Sustainable Activities, Brussels, 2022.
[6]OECD. Developing Sustainable Finance Definitions and Taxonomies, Paris, 2021.
[7]European Commission. EU Taxonomy for Sustainable Activities, Brussels, 2022.
[8]International Capital Market Association (ICMA). Green Bond Principles, London, 2023.

China has developed a national taxonomy of green projects focused on domestic sustainable development priorities, and is working to align it with international standards. International financial institutions, including the World Bank and regional development banks, are actively using green bonds to finance climate and infrastructure projects, promoting the dissemination of best practices in green finance in developing countries.

It's worth noting that in 2023, one of China's largest commercial banks, The Industrial and Commercial Bank of China (ICBC), achieved significant results in green financing in the areas of wind energy, clean transportation, solar energy, energy-saving, and environmental projects. These projects not only provide financial support for green transformations in the country but also effectively contribute to environmental conservation. China Construction Bank launched a Low Carbon Loan product designed to provide financial support for energy conservation and emission reduction. The bank has supported a number of green projects for industrial upgrading through the construction of energy-efficient buildings and green industrial parks. Bank of China has diversified its green financial products and launched funds that specialize in investing in green development projects. Bank of China is actively involved in the carbon finance market to help enterprises optimize carbon management. Below are some key trends in the development of green banking. Integration of policy support and market mechanisms. The Chinese government is actively promoting policies related to green finance, creating a solid foundation for green banking. In the future, as policies are further refined, market mechanisms for green banking will gradually expand. The Chinese government has developed important policy documents, such as the "Catalogue of Green Bond-Supported Projects" and the "Green Finance Evaluation Program", which provide standards and support for the implementation of green financial products. For example, in 2023, the Ministry of Finance and the People's Bank of China (PBOC) jointly released the Green Finance Development Plan (2023–2027), which proposes strengthening financial support for green projects and supporting the development of green loans, green bonds, and other financial instruments. Furthermore, the government provides dedicated green finance funds through policy banks and commercial banks to facilitate investment in green projects[9].

Green Finance Support Mechanisms in Developed Countries United Kingdom. The UK government has high ambitions to create a low-carbon, energy-efficient and environmentally sustainable economy. Active efforts to transition to a green economy in the United Kingdom began with the adoption of the Climate Change Act 2008, which aims to reduce carbon dioxide emissions by 80% by 2050 compared to the 1990 baseline. However, not only national environmental goals were defined, but also European Union (hereinafter referred to as the EU) goals: achieving 15% of all energy production from renewable sources (EU Renewable Energy Directive); recycling 50% of household waste by 2020 and reducing the landfill of biodegradable municipal waste by 35% by 2020 compared to 1995 (EU Waste Framework Directive), etc.[10]. But the transition to a green economy in the UK requires significant investment. For example, at least £100 billion is needed in energy (renewable energy, carbon capture and storage, electricity transmission, etc.); approximately £10 billion by 2020 for renewable heat; and £14 to £21 billion for home energy efficiency. The Green Investment Bank (GIB) Commission has identified a number of barriers hindering investment in green projects in the UK[11]. An independent and non-partisan advisory group convened by the UK Chancellor of the Exchequer to support and attract private sector investment in a low-carbon economy as investment market capacity limits and balance sheet constraints; political and regulatory risks; lack of investor confidence given technology risks, a lack of transparency in government policy, and high capital requirements for commercialization; difficulty attracting institutional investors to large numbers of small, low-carbon projects. The Green Investment Bank (GIB), which began operations in October 2012, was established by the UK government to address these barriers and attract investment in green projects. The main objectives of this institution are to eliminate market failures and stimulate private sector investment in green infrastructure projects. The Bank uses the following main instruments: loans and equity investments, investment fund financing, and guarantees[12]. To date, the Green Investment Bank has committed £2.3 billion to 58 projects across a range of sectors, mobilizing £7.8 billion of private capital, with £3 of additional private capital coming in for every £1 invested by the government[13]. Another instrument of government support for green project financing is the British Business Bank, whose primary goal is to increase financing for small and medium-sized businesses. This bank does not provide financial resources directly, but rather operates through partners. For example, the VC Catalyst Fund program, which supports venture capital funds, is a key player in this area.

South Korea Global warming, high dependence on fossil fuels and the economic crisis have served as preconditions for the transition to a green economy.

The transition to a green economy began in earnest with the announcement of the national "low-carbon

[9]https://www.climatepolicyinitiative.org/publication/green-banking-in-china-emerging-trends/

[10]HM Government. Update on the design of the Green Investment Bank. 2011. URL: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/31825/11-917-update-design-green-investment-bank.pdf

[11]Green Investment Bank Commission. Unlocking investment to deliver Britain's low carbon future // Report. London: Green Investment Bank Commission. 2010. URL: https://www.e3g.org/docs/Unlocking_investment_to_deliver_Britains_low_carbon_ future_-_Green_Investment_Bank_Commission_Report_June_2010.pdf

[12]UK Green Investment Bank. Annual Report 2014. Edinburgh. 2014. URL: http://www.greeninvestmentbank.com/media/25360/ar14-web-version-v2-final.pdf

[13]Department for Business, Innovation & Skills. Future of UK Green Investment Bank plc // Policy paper BIS/15/630. 2015. 24 p. URL: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/477493/BIS-15-630-future-of-the-ukgreen-investment-bank.pdf

green growth" strategy by President Lee Myung-Bak in November 2008. To implement this strategy, a five-year green growth plan (2009–2013) was adopted in July 2009. According to the plan, US$83.6 billion, which is 2% of the gross domestic product, is to be spent[14]. The Korean government is focusing primarily on large-scale construction projects within the framework of the "Green New Deal" (restoring four major rivers, building 1 million green homes by 2020, high-speed rail, etc.). The first five-year plan also discusses a strategy to attract private investment in this area and includes the following steps[15]:

Figure 1. South Korea's Five-Year Green Growth Plan[16]

In the course of implementing this strategy, Korean business groups invested 15.1 trillion won (approximately $13.6 billion) in the green sector, up from 2.4 trillion ($2.2 billion) in 2008, 5.4 trillion ($4.9 billion) in 2009, and 7.3 trillion ($6.6 billion) in 2010. These figures represent a 74.5% increase in annual investment between 2008 and 2010. According to the OECD report (OECD Economic Surveys: Korea 2012), the main factor hindering private investment in green business and innovation is the availability of financing, especially at the start-up stage. Traditional mechanisms cannot be used due to risks, such as information asymmetry. Therefore, to improve access to finance, the government passed the Framework Act on Low Carbon, Green Growth, which establishes and requires the government to develop financial instruments to provide direct financial support to green businesses and encourage private investment in green infrastructure projects[17]. Green financing in South Korea is provided through bank loans and loan guarantees. It can also be implemented through the venture capital market. Green bank loans are provided through conventional commercial banks and public financial institutions. In Korea, 75% of all green loans are provided by publicly funded banks. There are three types of green lending: direct lending, refinancing, and green deposit schemes[18]. Direct lending is carried out through government-funded banks directly to "green" companies. The scheme, where the government directs funds to commercial banks through the Korea Finance Corporation (KoFC) and then to "green" companies, is called on-lending. In the "green" deposit scheme, the government does not participate directly, but offers tax breaks to those who invest in "green" projects at a low interest rate. Credit guarantees are provided in South Korea by two main financial institutions: the Korea Credit Guarantee Fund (KODIT) and the Korea Technology Finance Corp. (KIBO). Also of special note is the Export-Import Bank of Korea (KEXIM), which issued "green" bonds in the amount of US$500 million for a five-year term with a coupon income of 1.75%. It uses various types of lending (export and import loans, guarantees, etc.)[19]. But other financial institutions in Korea are also investing

[14]UNEP. Overview of the Republic of Korea's National Strategy for Green Growth. 2010. URL: http://www.unep.org/PDF/PressReleases/201004_unep_national_strategy.pdf

[15]Zelenovskaya E. Green growth policy in Korea: a case study. International Center for Climate Governance. URL: http:// www.iccgov.org/wp-content/uploads/2015/05/08_reflection_june_2012.pdf

[16]Prepared by the author.

[17]OECD. OECD Economic Surveys: Korea 2012. 2012. 146 p. URL: https://books.google.ru/books?id=prlEtEgVnjkC/

[18]Kim Hyoung-tae. System Architecture for Effective Green Finance in Korea // Korea's Economy. 2011. T. 27. Pp. 18–24. URL: http://www.keia.org/sites/default/files/publications/30848_kimht_sp.pdf

[19]Korea Eximbank. GreenBond // KOREA EXIMBANK GREEN BOND NEWSLETTER. 2015. URL: http://ehf.koreaexim. go.kr/File.down?file=/attach_file/conts/kr/bank/Green %20Bond %20Investor %20Letter.pdf

in the green sector. For example, Kookmin Bank (the country's largest lender) established a 330 billion won Renewable Energy Direct Investment Fund with the government and allocated 750 billion won for investments in low-carbon, green growth industries[20]. To reduce information risk, South Korea has a green certification system, which is outlined in the Framework Act on Low Carbon, Green Growth. It consists of two components such as the Green Certification Committee (GCC) and the Korea Institute of Advancement of Technology (KIAT). The GCC determines which technologies and projects qualify for green certification based on the assessment of the Korea Institute of Advancement of Technology (KIAT)[21].

Germany was one of the first countries to implement "green" policies, having put forward its first federal environmental program in 1971[22]. In 1973, the first oil crisis led to a sharp increase in the price of oil, which led to the adoption of the Energy Conservation Act (EnEG) in 1976. This act encouraged investments in environmental protection through interest rate subsidies[23]. In July 2007, following the G8 meeting, the German government set targets no less ambitious than those of the UK for 2020, compared with 1990[24].

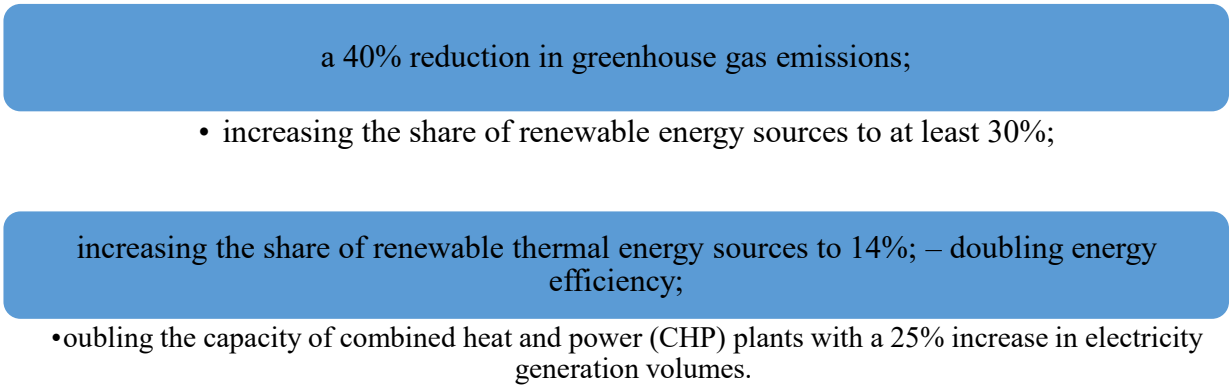

Figure 2. Green policy priorities in Germany[25]

Since 2007, the German government has issued a number of measures aimed at achieving these goals, which include various environmental regulations and requirements (e.g., from January 1, 2009, owners of new homes must provide heating and cooling from renewable energy sources; setting limits on greenhouse gas emissions from vehicles; tax breaks for the implementation of energy management systems in enterprises from 2013, etc.)[26]. State financial support for green projects in Germany is provided by the national investment bank Kreditanstaltfür Wiederaufbau (KfW), which was established in 1948 to implement the Marshall Plan. The bank is jointly owned by the German federal government (80%) and the states (20%)[27]. KfW's main areas of environmental financing are renewable energy, energy efficiency, and low-carbon transport. In 2011, €22.8 billion was allocated for environmental financing, accounting for one-third of the bank's funding for incentive and development programs. The bank supports green projects through the following instruments[28].

[20]Kim Jae-Kyoung. Korea Braces for Green Finance Era // The Korea Times. 2009. URL: http://www.koreatimes.co.kr/www/news/biz/2015/12/283_49962.html

[21]OECD Economic Surveys: Korea 2012. 2012. 146 p. URL: https://books.google.ru/books?id=prlEtEgVnjkC/

[22]Gill, Indermit S., Raiser, Martin (2013). Golden growth: restoring the lustre of the European economic model (Vol. 3): Country benchmarks. Washington DC, World Bank. 2013. URL: http://documents.worldbank.org/curated/en/394981468251372492/pdf/681680PUB0v30G00Box379869B00PUBLIC0.pdf

[23]Schröder M. et al. The KFW experience in the reduction of energy use in and CO2 emissions from buildings: operation, impacts and lessons for the UK. UCL Energy Institute. 2011. 77 p. URL: http://sticerd.lse.ac.uk/dps/case/cp/KfWFullReport.pdf

[24]Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMUB). Green Recovery: The Way out of the Economic Crisis. Berlin: BMU. 2009. URL: https://www.germany.info/contentblob/2618342/Daten/676538/BMU_GreenRecovery_DD.pdf

[25]Prepared by author.

[26]Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Climate Protection in Figures. Facts, Trends and Incentives for German Climate Policy. 2014. URL: http://www.phnom-penh.diplo.de/contentblob/4549730/Daten/4583205/Climate_Protection.pdf.

[27]Christopher J. Wigley. Chapter 15. Revitalizing the Green Investment Bank // The Green Book: New Directions for Liberals in Government / ed. D. Brack. London: Biteback Publishing. 2013. 384 p. URL: https://books.google.ru/books?id=JwKuAwAAQBAJ/

[28]Hubert R., Cochran I. Public Finance Institutions & the Low-Carbon Transition Case Study: KfW Bankengruppe // CDC Climat Research. 2013. URL: http://www.i4ce.org/wp-core/wp-content/uploads/2015/10/14-09_kfw_case_study.pdf

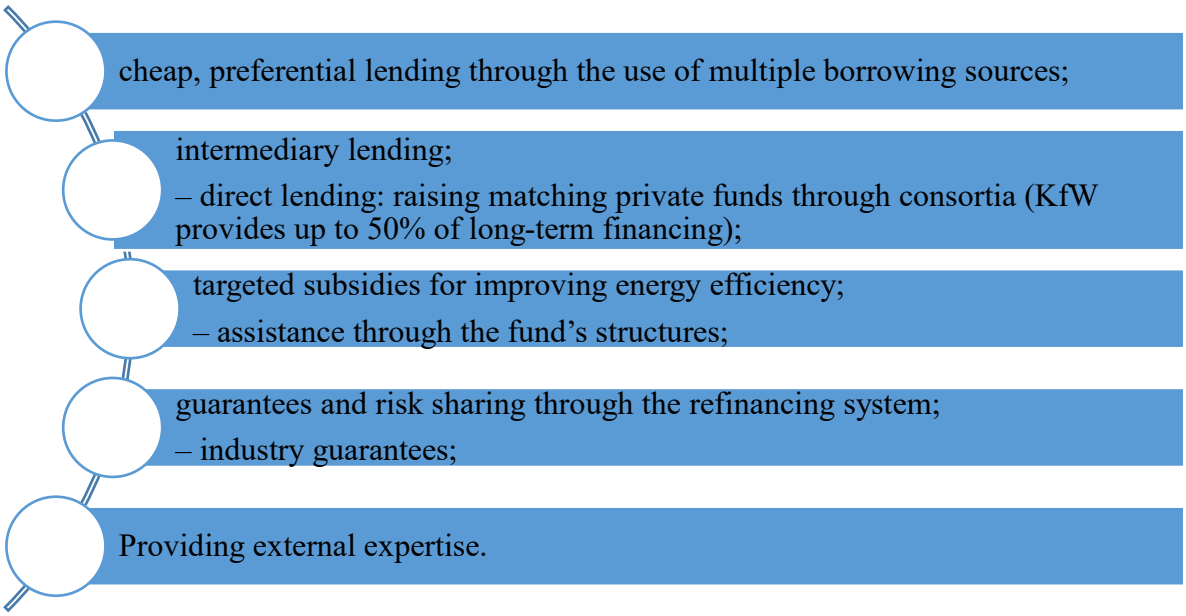

Figure 3. Tools to support green projects in banks

The bank's investment activities are primarily carried out by providing preferential loans through lending to local financial institutions. For large-scale project financing, KfW provides direct lending at market rates, eliminating the market gap[29]. KfW Bank is financed by private and public funds. However, the most important sources of funding for the bank are international capital and money markets. More than 90% of the bank's capital comes from capital markets, and in 2010, more than €76 billion was raised from international capital markets[30]. One of the instruments for attracting financing for KfW's green projects are green bonds. The bank issued its first green bonds in 2014 for a total of €2.7 billion. One separate measure of state support for financing green projects in Germany is the Feed-in Tariff (FIT), which encourages investments in renewable energy sources. This program was first established in Germany by the Stromeinspeisungsgesetz (StrEG) (Electricity Feed-in Act) in 1990, and by the Erneuerbare-Energien-Gesetz (EEG) (Renewable Energy Act) in 2000. According to this program, it is necessary to connect producers of electricity from renewable sources and purchase this electricity. Financing of this program is carried out by distributing costs among all consumers, which guarantees low electricity prices[31]. In addition to the state-owned investment bank, there are a number of financial institutions in Germany that offer "ethical financial products" (environmentally and socially oriented) or "ethical banking" as GLS bank, TriodosBank, Umweltbank, EthikBank.

4. Analysis and results of the research.

The analysis shows that the ICMA Green Bond Principles and EU Taxonomy serve complementary functions within the system of international green finance standards. The ICMA Principles focus on the financing process and disclosure, establishing requirements for the intended use of funds, revenue management, and issuer reporting. In contrast, EU Taxonomy is based on a classification approach and defines specific environmental objectives, including climate change mitigation and adaptation, as well as technical criteria for assessing project sustainability. This promotes the unification of approaches to assessing green investments and increases investor confidence. An analysis of international practice confirms that the use of taxonomy reduces information asymmetry in financial markets and improves the efficiency of capital allocation. However, developing economies still need to adapt international standards to their national conditions and institutional environments.

5. Conclusion.

The research concludes that international green finance standards are a key factor in the development of sustainable financial markets. The ICMA Green Bond Principles ensure the flexibility and scalability of green financial instruments, while the EU Taxonomy establishes uniform and clear criteria for environmental sustainability.

The comprehensive use of these standards helps reduce the risks of greenwashing, increase the transparency of financial flows, and attract long-term investment in environmental projects. International experience can be used to develop national green finance models and integrate ESG principles into public financial policies.

[29]Hubert R., Cochran I. Public Finance Institutions & the Low-Carbon Transition Case Study: KfW Bankengruppe // CDC Climat Research. 2013. URL: http://www.i4ce.org/wp-core/wp-content/uploads/2015/10/14-09_kfw_case_study.pdf

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GEOGRAPHICAL SCIENCES

SEASONAL ENVIRONMENTAL CONDITIONS OF THE BULGARIAN DANUBE RIVER AND THEIR RELEVANCE FOR RIVER-BASED TOURISM

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Abstract

River-based tourism is strongly influenced by environmental seasonality, particularly in large rivers such as the Danube. This study examines the seasonal atmospheric and hydrological conditions along the Bulgarian coast of the Danube River using 24 years of mean monthly data. Mean monthly air temperature, air pressure, relative humidity, river water temperature, and river levels from six ports are analyzed alongside ice occurrence statistics from five stations. The analysis focuses on recurring seasonal regimes and their implications for tourism suitability, accessibility, and operational constraints. The results indicate a pronounced seasonal structure governing river usability, with a relatively long period of favorable conditions for tourism activities and a limited winter constraint linked to ice formation. The study provides an environmental baseline for tourism planning.

Keywords: Danube river, river tourism, river navigability, environmental data.

Introduction

Tourism activities in are mostly shaped by environmental variability and seasonal accessibility. Inland waterways such as the Danube support a wide range of tourism products, including river cruises, recreational boating, angling, waterfront cultural tourism, and nature-based activities.

Along the Bulgarian stretch of the Danube, tourism development remains closely tied to navigability, climatic comfort, and the reliability of hydrological conditions (Ivanova P., 2015). Understanding the typical seasonal environmental conditions should be a first prerequisite for assessing tourism viability.

The factors which contribute for the development of cruise tourism on the Danube River are:

1. Resource availability of riverside destinations, namely:

- a wealth of recreational, natural, anthropogenic, and cultural-historical resources;
- opportunities for practicing specialized types of tourism in riverside areas and cities, such as ornithological, ecological, ethnographic, adventure, route-exploration, educational, religious, etc.;
- good transport infrastructure, proximity and easy access to tourist sites in the interior of the country.

2. Favourable navigation conditions on the river throughout all seasons.

3. Established network of passenger terminals in most port cities.

4. Presence of a panoramic view along the river.

Unlike studies focused on climate change detection, this research utilizes mean monthly climatological data aggregated over a 24-year period. While this limits the ability to assess temporal change, it enables a detailed characterization of "normal" seasonal conditions that tourists, operators, and planners are most likely to encounter.

In this article, the author presents an analysis of the navigation conditions in the Bulgarian section of the Danube as a key prerequisite for the development of cruise tourism in the northern part of the country. A large amount of statistical data has been processed and presented, obtained with the kind assistance of the official state institutions – the Executive Agency "Study and Maintenance of the Danube River" (EAEMDR), which is responsible for maintaining the river's navigability.

The aim of this study is to present the environmental seasonality along the Bulgarian Danube in terms of tourism-environment interactions, focusing on river accessibility and winter constraints related to ice occurrence.

Literature analysis

The Bulgarian part of the river is in the lower reaches, which are characterized by greater width, calmer waters, and more densely populated coastal areas. Unfortunately, however, cruise tourism on the Danube is underdeveloped. Bulgarian tourist ships account for only 1% of all ships on the river. Specialized tourist infrastructure (with the exception of passenger ports) is virtually non-existent in the country, while it is present in all other Danube countries (Vasileva, 2010).

The navigation situation throughout the year and its impact on the development of cruise tourism is an integral part of the overall description of the factors that determine the success of the river tourism. With its 2,414 navigable kilometers (Danube Commission 70, 2019), the Danube provides ample opportunities for both commercial freight transport and tourist transport. The river passes through or along the borders of nine European countries (Dávid & Madudová, 2019)., making it particularly interesting for tourist trips.

The characteristics of river navigability and aspects for cruise tourism have been described by a number of Bulgarian and foreign researchers. The literature review on these issues includes publications from the

last twenty years, which shows that interest in the research problem is relatively recent. Kabakchieva and Karcheva present the advantages and disadvantages of river cruise tourism by comparing it to sea cruise tourism (Kabakchieva D., Karcheva T., 2019). Seasonality, frequent shore excursions, and diverse landscapes are some of the characteristics that determine whether conditions are suitable or less suitable for the development of this industry (Mavrova-Guirguinova, 2020), (Ioana-Toroimac & Vîrghileanu, 2025).

River cruise tourism is popular throughout the world. In her study entitled "River Tourism," Vasileva V. reviews the major rivers around the world where various types of tourist services are offered (Vasileva V., 2010). Vasileva identifies the Danube as one of the major rivers in Europe with enormous potential for the development of the industry. The popularity of this tourist product in Europe is also aided by some secondary factors such as the dense population of the continent, a culture of demand for the product, concentration of remarkable sites of cultural, research, cognitive, religious, and other interest (Marinov V. et al., 2014).

Research methodology and analysis

The study draws on:

- Mean monthly air temperature, air pressure, and relative humidity from six ports
- Mean monthly river water temperatures and river levels from the same locations
- Annual statistics on ice formation and complete freezing from five stations

All statistics show multi-year mean monthly values, capturing recurring seasonal patterns rather than interannual variability.

Given the aggregated nature of the dataset, the analysis is explicitly descriptive and relational rather than predictive. The study does not infer trends or future changes but examines:

- Seasonal distributions
- Spatial differences along the Bulgarian Danube
- Environmental conditions relevant to tourism use

This approach aligns with tourism-environment research, where baseline environmental suitability often matters more than long-term climatic change signals.

The study is based on primary and secondary data, which include observation, examination of extensive statistical material, analysis of hydrometeorological information.

To achieve the objectives of the study, the author sought the cooperation of the state authorities Executive Agency “Study and Maintenance of the Danube River” (EAEMDR) and IAMA. The data and results shown cover different periods over the last thirty years.

Analysis of the results

The Danube River is the only inland waterway in the Republic of Bulgaria. The Bulgarian section is located in its lower course. Navigation on the river is permitted in the deepest water area, which is marked with buoys and is well maintained. The EAEMDR, which is responsible for maintaining the waterway provides information on the navigational situation, meteorological and hydrological information for ships sailing in the Bulgarian section. The following river water level ranges have been adopted to establish the navigation regime (Danube Commission, 2019):

- Low level – below 200 cm;
- Medium level – from 200 to 500 cm;
- High level – above 500 cm.

Navigation conditions are undoubtedly the most important factor that contributes to or hinders the development of cruise tourism on the Danube. Seasonal changes in weather conditions lead to the appearance and existence for a certain period of time of phenomena such as ice drift, freezing of sections of the river, falling water levels, and the appearance of rapids. During some periods of the year when the water level of the river is below the minimum navigable level, sections of difficult navigation are formed. At critically low water levels, navigation is suspended. The Republic of Bulgaria is a party to the 1948 Belgrade Convention and the 1955 agreement between the then People's Republic of Bulgaria and the Romanian People's Republic. Under these agreements, Bulgaria is obliged to maintain and improve the fairway, the part of the river where a safe depth for navigation is ensured.

The navigation conditions on the Danube River change rapidly throughout the different seasons of the year. The strategic objectives of the EAEMDR include activities that help maintain the waterway in a usable condition throughout the year. The agency has the resources to make adjustments to the waterway and install additional navigation marks to ensure the safety of navigation (EAEMDR, 2020). Meteorological conditions are the main factor contributing to specific navigational difficulties for shipping, such as thresholds, changes in the curvature of bends, ice drift, freezing, etc. Twenty five-year statistics for the period from 1994 to 2018 show similar conditions of hydrometeorological elements along the entire length of the Bulgarian section. Data from the meteorological stations "Novo Selo," "Lom," "Oryahovo," "Svishtov," "Ruse," and "Silistra" refer to the following elements:

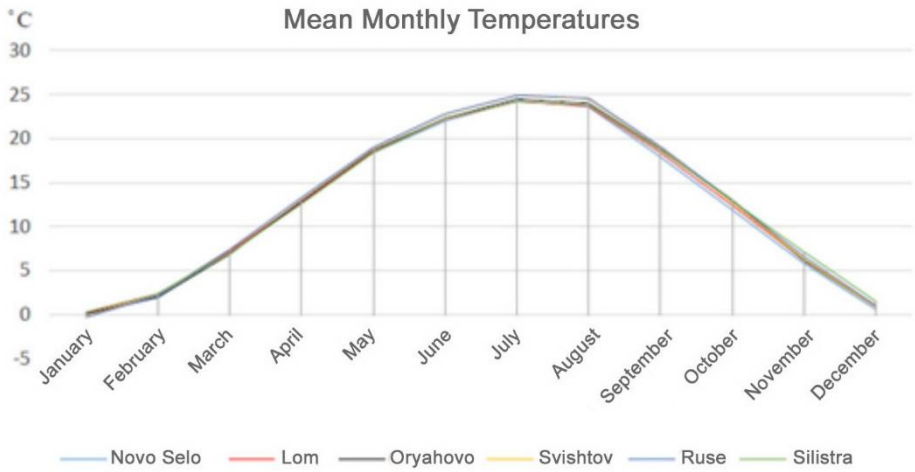

Fig. 1. Mean monthly temperatures for the period between 1994 and 2018 for the Bulgarian coastline of the Danube.

Source: EAEMDR

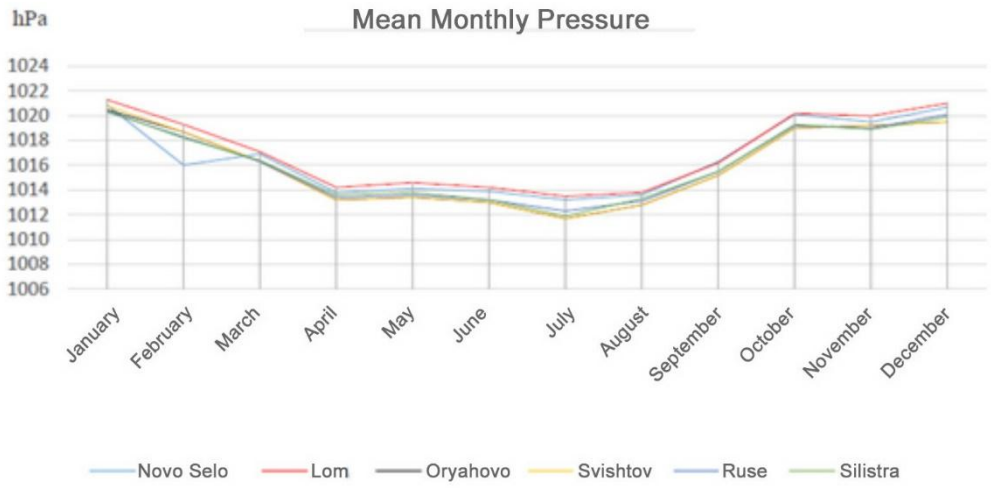

Fig. 2. Mean monthly atmospheric pressure for the period between 1994 and 2018 for the Bulgarian coastline of the Danube.

Source: EAEMDR

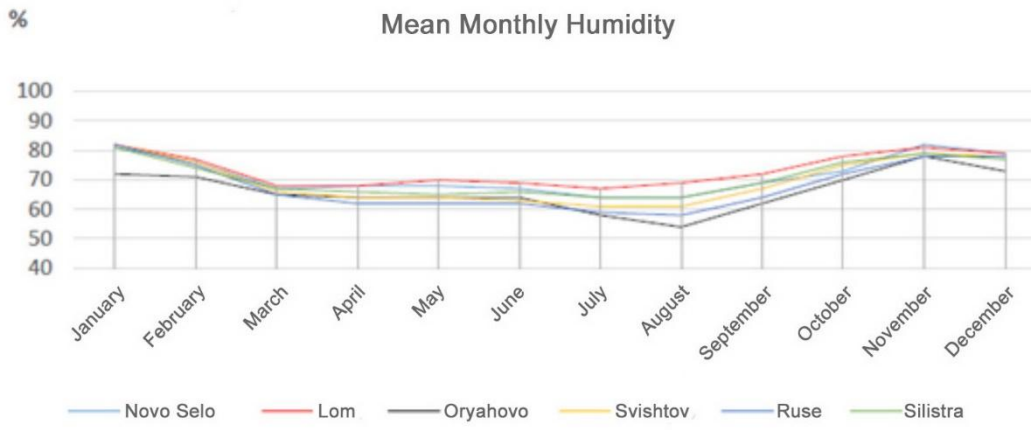

Fig. 3. Mean monthly air humidity for the period between 1994 and 2018 for the Bulgarian coastline of the Danube.

Source: EAEMDR

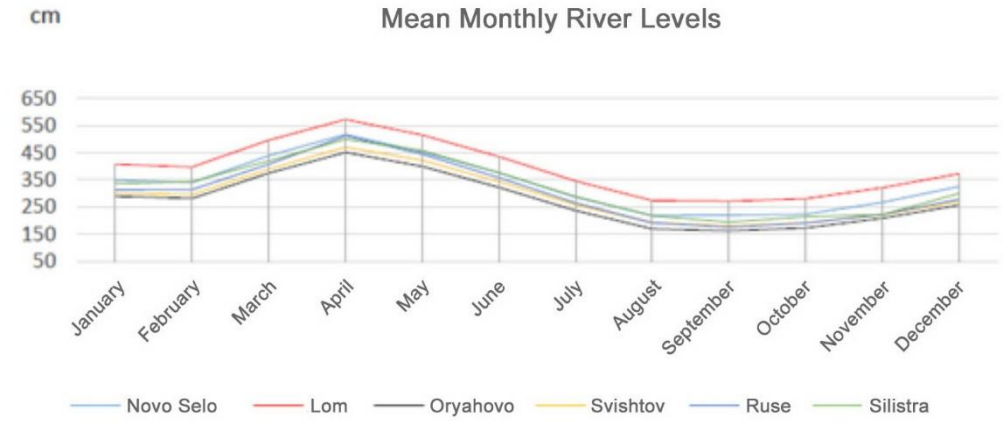

Fig. 4. Mean monthly Danube river levels for the period between 1994 and 2018 for the Bulgarian coastline.
Source: EAEMDR

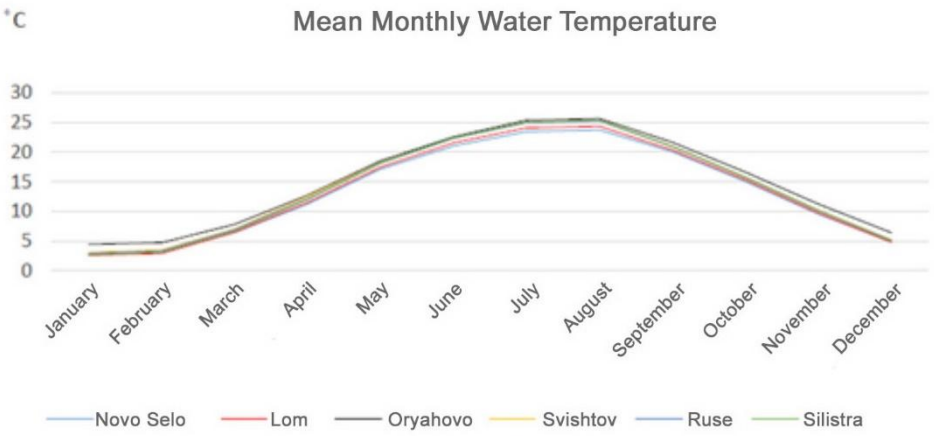

Fig. 5. Mean monthly water temperature levels for the period between 1994 and 2018 for the Bulgarian coastline of the Danube.

Source: EAEMDR

The above-mentioned meteorological elements create conditions for one of the most dangerous situations for navigation on the river – the occurrence of freezing and ice drift.

The Bulgarian section of the Danube provides favorable conditions for navigation even during the winter period. Ice formation is restricted to winter months and affects only part of the year. From a tourism perspective, ice occurrence represents a predictable seasonal constraint rather than a persistent risk. Stations with lower winter water temperatures and lower river levels experience more frequent ice formation, limiting navigation-based tourism during this period.The meteorological factors that cause the water to freeze are air temperature, water temperature, and water level. Figures 1, 4, and 5 show that from December to the end of March, conditions are potentially suitable for freezing. Fifteen -year statistics from 2007 to 2023, provided by the EAEMDR, show that ice phenomena in the Bulgarian section of the Danube River are becoming increasingly rarer. The confinement of ice to a narrow seasonal window suggests that tourism planning can effectively avoid this constraint. However, with the advent of global warming, the risk of ice phenomena is becoming particularly small, as seen from the ice conditions figures below. The data below describe the state of ice phenomena from the control stations in Novo Selo, Vidin, Svishtov, Ruse, and Silistra. This provides an overview of the entire section of the river from Novo Selo to Silistra (Figs. 6 and 10) and the main ports with a real share in cruise ship services, Vidin, Svishtov, and Ruse (Figs. 7, 8, and 9).

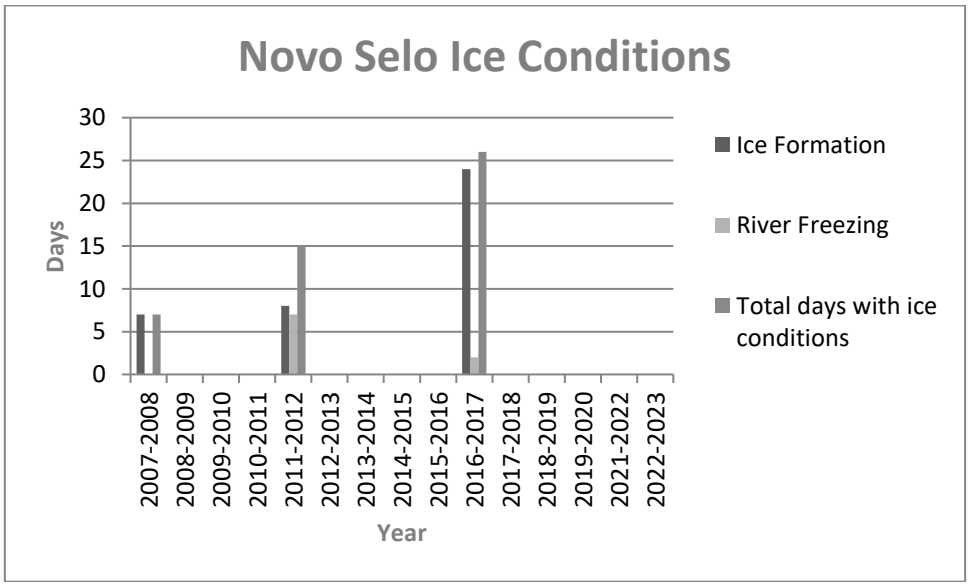

Fig. 6. Ice conditions at Novo Selo, км 833,6

Source: EAEMDR

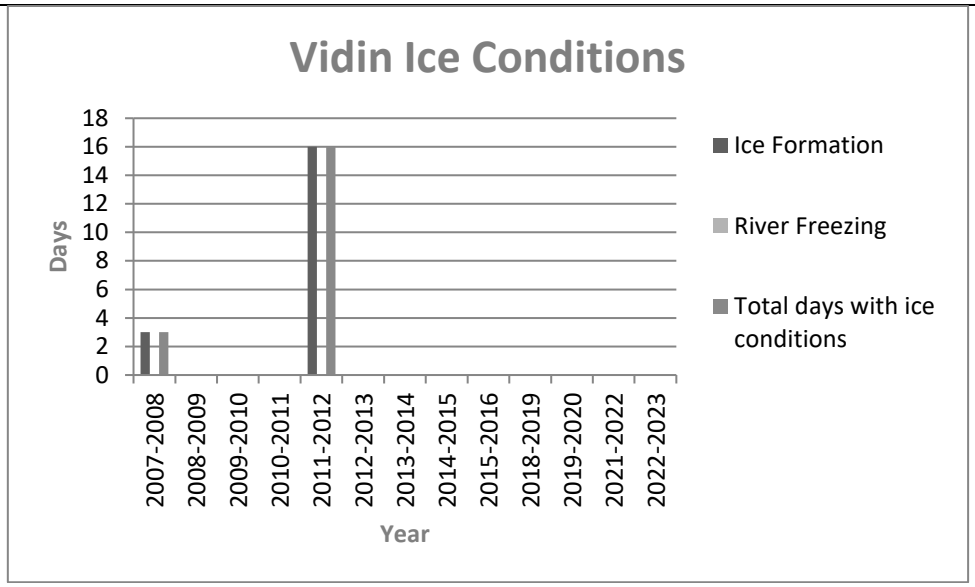

Fig. 7. Ice conditions at Vidin, км 790,2

Source: EAEMDR

Fig. 8. Ice conditions at Svishtov, км 554,3

Source: EAEMDR

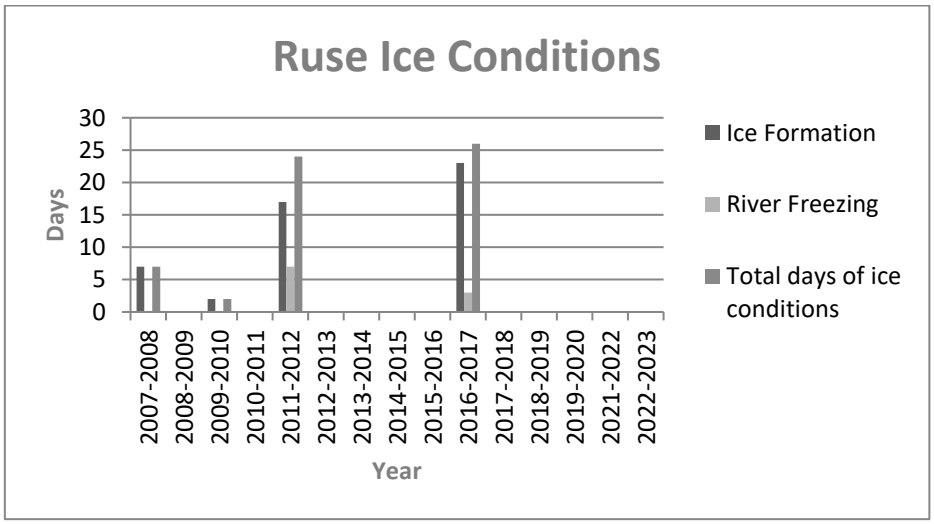

Fig. 9. Ice conditions at Ruse, км 495,6

Source: EAEMDR

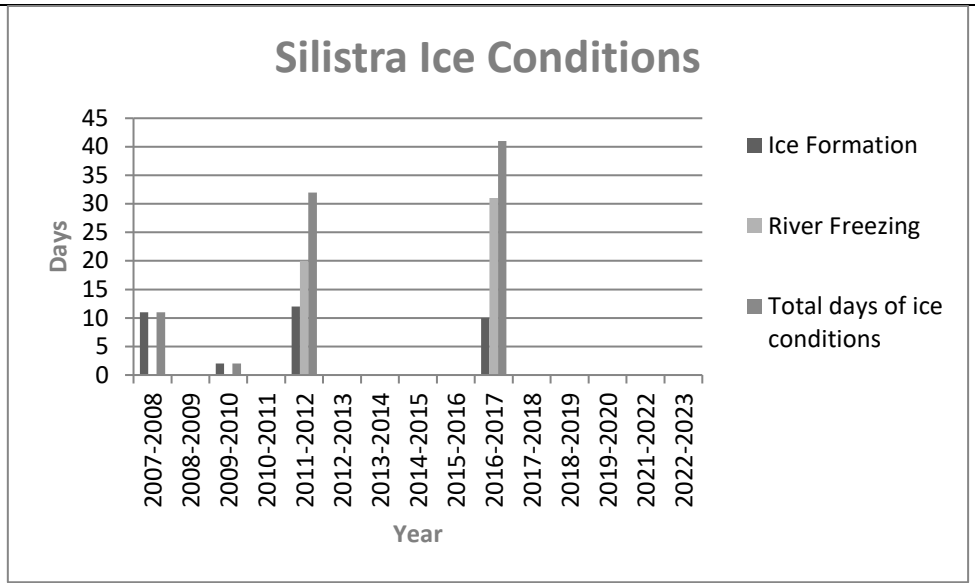

Fig. 10. Ice conditions at Silistra, км 375,5

Source: EAEMDR

The above data show that the Danube River offers good navigational conditions, even during the winter season. Ice formation is possible when meteorological and hydrological factors coincide – a prolonged period of sub-zero air temperatures below -5°C and low water levels, i.e. 250 cm and below. Over the last 15-20 years, navigation difficulties have occurred during the periods 2007-2008, 2011-2012, and 2016-2017 for about 25-30 days, when partial freezing of the river was observed. Ice drift is also considered a risk to navigation due to the potential danger of damage to the propulsion and control systems of ships. Statistics show that these phenomena are rare on the Bulgarian section of the Danube, which makes it navigable almost all year round.

Mean monthly air temperatures define a clear gradient throughout the year. The winter months of December, January and February are characterized by low temperatures and low river levels potentially creating suitable ice phenomena conditions, while late spring, summer, and early autumn provide thermally favorable conditions for safe navigation along the Danube.

Relative humidity and air pressure exhibit seasonal variability that influences perceived comfort and weather stability.

Water temperature follows atmospheric seasonality with a damped amplitude. Warmer water temperatures during late spring and summer enhance recreational activities such as boating, fishing, and riverside leisure tourism. Mean monthly river levels indicate seasonal variability that affects navigability and access to river infrastructure. High spring water levels generally support cruise tourism and navigation, while late summer low-water conditions may impose operational limitations on larger vessels.

The results provide an environmental baseline that tourism planners and stakeholders can use to align infrastructure, marketing, and activity scheduling with typical river conditions.

In maintaining navigability, the responsible Bulgarian institutions are also guided by the established European standards for the dimensions of the fairway - a minimum depth of 2.50 m at low water levels, a width of 180 m, and a curve radius of 1,500 m under all conditions, both during daylight and nighttime hours.

Discussion and conclusions

The information presented so far shows that the factor of "navigation conditions" should not be considered a limiting factor for the development of cruise tourism on the Bulgarian section of the Danube. Over the last years, there has been a noticeable improvement in the infrastructure to and around tourist sites of interest in the country.

The seasonal environmental regime of the Bulgarian Danube supports a relatively long tourism-operational season. Spring and autumn emerge as particularly favorable periods, combining thermal comfort, navigability, and scenic value. Winter tourism remains limited due to ice occurrence and low temperatures, while summer tourism may occasionally be affected locally by low water levels. These findings highlight the importance of seasonally adaptive tourism products rather than uniform year-round development.

This study demonstrates how mean monthly environmental data can be effectively used to assess tourism-relevant river conditions without relying on trend analysis. The Bulgarian Danube exhibits a well-defined seasonal structure, offering extended periods suitable for river-based tourism while maintaining predictable seasonal constraints. This finding is essential for sustainable tourism development, particularly in river corridors with multifunctional economic and environmental roles.

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JURIDICAL SCIENCES

ПОМ'ЯКШЕННЯ ТА ОБТЯЖЕННЯ ВІДПОВІДАЛЬНОСТІ ЗА УЧАСТЬ В АНТИКОНКУРЕНТНИХ УЗГОДЖЕНИХ ДІЯХ: СУЧАСНІ ПІДХОДИ ТА ПРАКТИКА ЗАСТОСУВАННЯ

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MITIGATION AND AGGRAVATION OF LIABILITY FOR PARTICIPATION IN ANTI-COMPETITIVE CONCERTED ACTIONS: MODERN APPROACHES AND APPLICATION PRACTICE

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Анотація

У статті досліджуються сучасні підходи до застосування механізмів пом'якшення та обтяження відповідальності за участь суб'єктів господарювання в антиконкурентних узгоджених діях як ключового елементу державної конкурентної політики. Акцент зроблено на аналізі поєднання каральних і стимулюючих інструментів відповідальності, спрямованих не лише на покарання порушників, а й на виявлення та запобігання латентним формам антиконкурентної поведінки, зокрема картельним змовам.

Обґрунтовано, що антиконкурентні узгоджені дії характеризуються підвищеним рівнем суспільної небезпеки через їх прихований характер, координацію поведінки конкурентів та значний негативний вплив на функціонування ринків, результати публічних закупівель і механізми ціноутворення. У зв'язку з цим ефективність протидії таким порушенням значною мірою залежить від здатності антимонопольних органів використовувати диференційований підхід до відповідальності з урахуванням ролі суб'єкта у змові, ступеня сприяння розслідуванню та наслідків порушення для конкуренції.

У статті проаналізовано правову природу штрафних санкцій як базового інструменту відповідальності за антиконкурентні узгоджені дії та доведено, що виключно репресивна модель правозастосування не забезпечує належного рівня викриття картелів. У цьому контексті особливу увагу приділено механізмам пом'якшення відповідальності, насамперед програмам звільнення або зменшення штрафів (leniency policy), які розглядаються як ефективний засіб стимулювання учасників змови до добровільного розкриття інформації та надання доказів антиконкурентної поведінки. Підкреслено, що успішність застосування leniency policy залежить від чіткості нормативного регулювання, передбачуваності правових наслідків і рівня довіри бізнесу до антимонопольних органів.

Окрему увагу приділено аналізу обтяжуючих обставин, що враховуються при визначенні міри відповідальності за антиконкурентні узгоджені дії, зокрема повторності порушень, ініціативної ролі суб'єкта у змові, перешкоджання розслідуванню та ухилення від виконання рішень антимонопольного органу. Розглянуто заборони на участь у процедурах публічних закупівель як додатковий інструмент впливу, що має виражений превентивний характер і безпосередньо впливає на економічні інтереси порушників.

На основі аналізу національної практики та зіставлення її з європейськими підходами зроблено висновок про необхідність досягнення балансу між пом'якшуючими та обтяжуючими механізмами відповідальності з метою підвищення ефективності правозастосування у сфері захисту економічної конкуренції. Запропоновано напрями вдосконалення правового регулювання та практики застосування відповідних інструментів, зокрема шляхом підвищення прозорості процедур, розвитку аналітичних і цифрових інструментів виявлення змов та гармонізації національного законодавства з європейськими стандартами конкуренційної політики.

Abstract

The article examines modern approaches to the application of mechanisms for mitigating and aggravating liability for the participation of business entities in anticompetitive concerted actions as a key element of state competition policy. The emphasis is on the analysis of a combination of punitive and incentive liability instruments aimed not only at punishing violators, but also at identifying and preventing latent forms of anticompetitive behavior, in particular cartel collusion.

It is substantiated that anticompetitive concerted actions are characterized by an increased level of public danger due to their hidden nature, coordination of competitors' behavior and a significant negative impact on the functioning of markets, the results of public procurement and pricing mechanisms. In this regard, the effectiveness of countering such violations largely depends on the ability of antimonopoly authorities to use a differentiated

approach to liability, taking into account the role of the entity in the conspiracy, the degree of assistance to the investigation and the consequences of the violation for competition.

The article analyzes the legal nature of fines as a basic instrument of liability for anticompetitive concerted actions and proves that an exclusively repressive law enforcement model does not provide an adequate level of detection of cartels. In this context, special attention is paid to mechanisms for mitigating liability, primarily leniency programs or fine reduction programs (leniency policy), which are considered as an effective means of encouraging participants in a conspiracy to voluntarily disclose information and provide evidence of anticompetitive behavior. It is emphasized that the success of the application of leniency policy depends on the clarity of regulatory regulation, the predictability of legal consequences and the level of business trust in antitrust authorities.

Special attention is paid to the analysis of aggravating circumstances that are taken into account when determining the degree of liability for anticompetitive concerted actions, in particular, repetition of violations, the initiative role of the subject in the conspiracy, obstruction of the investigation and evasion of the implementation of decisions of the antitrust authority. Bans on participation in public procurement procedures are considered as an additional tool of influence, which has a pronounced preventive nature and directly affects the economic interests of violators.

Based on the analysis of national practice and its comparison with European approaches, a conclusion is drawn about the need to achieve a balance between mitigating and aggravating liability mechanisms in order to increase the effectiveness of law enforcement in the field of economic competition protection. Directions for improving legal regulation and the practice of applying relevant instruments are proposed, in particular by increasing the transparency of procedures, developing analytical and digital tools for detecting collusion, and harmonizing national legislation with European competition policy standards.

Ключові слова: антиконкурентні узгоджені дії, відповідальність, пом'якшення відповідальності, обтяжуючі обставини, leniency policy, штрафи, публічні закупівлі, конкурентне право.

Keywords: anticompetitive concerted practices, liability, mitigation of liability, aggravating circumstances, leniency policy, fines, public procurement, competition law.

Вступ. Забезпечення добросовісної конкуренції в сучасних умовах розвитку ринкової економіки потребує не лише виявлення та припинення антиконкурентних узгоджених дій, а й формування ефективної системи відповідальності за їх вчинення. У цьому контексті особливої актуальності набуває питання застосування таких правових інструментів, які здатні впливати на поведінку суб'єктів господарювання, поєднуючи каральну, превентивну та стимулюючу функції.

Антиконкурентні узгоджені дії характеризуються специфічним механізмом реалізації, що зумовлює обмежену ефективність виключно репресивних заходів впливу. Координація конкурентної поведінки часто здійснюється без формалізованих домовленостей, що потребує використання диференційованих підходів до відповідальності та індивідуалізації санкцій з урахуванням ролі суб'єкта у порушенні, тривалості антиконкурентної поведінки та ступеня його сприяння розслідуванню.

У сучасній конкурентній політиці поряд із штрафними санкціями сформувалися механізми пом'якшення відповідальності, зокрема програми звільнення або зменшення штрафів (leniency policy), які спрямовані на стимулювання добровільного розкриття антиконкурентних узгоджених дій і підвищення ефективності доказування. У праві Європейського Союзу такі інструменти розглядаються як складова комплексного підходу до протидії картелям, ефективність якого залежить від передбачуваності правових наслідків та рівня довіри бізнесу до антимонопольних органів.

Водночас система відповідальності за участь в антиконкурентних узгоджених діях передбачає застосування й обтяжуючих механізмів, спрямованих на диференціацію санкцій та посилення стримуючого ефекту правозастосування. Застосування таких заходів має ґрунтуватися на чітких і прозорих критеріях з метою забезпечення балансу між ефективністю протидії антиконкурентній поведінці та дотриманням принципів правової визначеності.

З огляду на це актуалізується необхідність наукового дослідження сучасних підходів до застосування механізмів пом'якшення та обтяження відповідальності за участь в антиконкурентних узгоджених діях, а також оцінки практики їх реалізації в національній системі захисту економічної конкуренції з урахуванням європейських стандартів конкуренційної політики.

Постановка проблеми. Незважаючи на наявність розгалуженої системи правових та організаційних засобів протидії антиконкурентним узгодженим діям, ефективність їх практичного застосування в Україні залишається обмеженою. Такі дії, зокрема картельні змови, і надалі характеризуються високим рівнем латентності, що ускладнює їх своєчасне виявлення, доведення та притягнення винних осіб до відповідальності. За цих умов ключового значення набуває не лише суворість санкцій, а й здатність правозастосовної системи формувати стимули для добровільного розкриття порушень і запобігання їх повторенню.

Чинне законодавство України про захист економічної конкуренції передбачає застосування як пом'якшуючих, так і обтяжуючих механізмів відповідальності за участь в антиконкурентних узгоджених діях. Водночас відсутність чітких і передбачуваних критеріїв їх використання, нерівномірність правозастосовної практики та обмежена прозорість відповідних процедур знижують ефективність цих інструментів і ускладнюють індивідуалізацію відповідальності учасників порушення.

Окремою проблемою є недостатня реалізація потенціалу програм пом'якшення відповідальності (leniency policy), які в міжнародній практиці довели

свою результативність як інструмент викриття антиконкурентних узгоджених дій. В українських умовах застосування таких механізмів стримується правовою невизначеністю, низьким рівнем довіри бізнесу до антимонопольних органів та ризиками негативних наслідків для суб'єктів господарювання, які погоджуються на співпрацю. Водночас надмірна орієнтація на штрафні санкції без належного врахування ролі суб'єкта у порушенні та ступеня його сприяння розслідуванню може знижувати загальний превентивний ефект конкуренційної політики.

Таким чином, постає наукова та практична проблема формування збалансованого механізму застосування пом'якшуючих і обтяжуючих заходів відповідальності за антиконкурентні узгоджені дії, який би поєднував ефективність викриття порушень, справедливість санкцій та відповідність європейським стандартам конкуренційного права. Вирішення цієї проблеми потребує комплексного аналізу чинного правового регулювання, практики Антимонопольного комітету України та можливостей адаптації кращих європейських підходів до національних умов.

Метою статті є комплексне дослідження механізмів пом'якшення та обтяження відповідальності за участь в антиконкурентних узгоджених діях, визначення їх ролі у системі протидії порушенням законодавства про захист економічної конкуренції, а також аналіз практики їх застосування в Україні з урахуванням європейських підходів.

Аналіз останніх досліджень. Питання відповідальності за участь в антиконкурентних узгоджених діях достатньо широко висвітлене у працях вітчизняних науковців, зокрема О. М. Клименка, М. Ю. Покальчука, Т. І. Швидкої, О. П. Віхрова, В. К. Малолітневої, Я. В. Петруненка, А. О. Олефіра, О. Л. Юдицького, А. О. Сошнікова та інших. У цих дослідженнях основну увагу зосереджено на правовій природі антиконкурентних узгоджених дій, механізмах їх виявлення та доведення, а також на застосуванні штрафних санкцій, насамперед у контексті картельних змов і спотворення результатів публічних закупівель. Водночас інститути пом'якшення та обтяження відповідальності, включаючи програми leniency, у науковій літературі розглядаються фрагментарно та переважно в порівняльному аспекті з правом Європейського Союзу. Недостатньо дослідженими залишаються питання визначеності критеріїв їх застосування, взаємозв'язку між поведінкою учасників порушення та індивідуалізацією санкцій, а також впливу цих механізмів на ефективність викриття латентних антиконкурентних узгоджених дій в українській правозастосовній практиці. Таким чином, сучасні дослідження не формують цілісного підходу до аналізу пом'якшення та обтяження відповідальності як взаємодоповнюючих інструментів конкурентної політики, що зумовлює необхідність подальшого наукового осмислення їх ролі та практики застосування в Україні з урахуванням європейських стандартів.

Виклад основного матеріалу. Забезпечення ефективного захисту економічної конкуренції в сучасних умовах розвитку ринкової економіки передбачає не лише формальне встановлення заборон на антиконкурентні узгоджені дії, а й формування дієвого, багаторівневого механізму юридичної відповідальності за їх вчинення. Особливе значення у цьому контексті мають інструменти, здатні одночасно виконувати каральну, превентивну та стимулюючу функції, впливаючи на мотивацію суб'єктів господарювання та їхню модель поведінки на ринку. Антиконкурентні узгоджені дії, насамперед у формі картельних змов, характеризуються високим рівнем латентності, колективним характером та значною економічною шкодою для функціонування ринків, результатів публічних закупівель і механізмів ціноутворення. Саме ці ознаки зумовлюють обмежену ефективність виключно штрафної (репресивної) моделі відповідальності, яка не забезпечує належного рівня викриття та припинення таких порушень.

У сучасній конкурентній політиці дедалі більшого значення набуває поєднання штрафних санкцій із механізмами договірного та стимулюючого характеру, зокрема програмами звільнення або пом'якшення відповідальності (leniency), а також інструментами примирення сторін (settlement), які дозволяють не лише оптимізувати процес доказування, а й дестабілізувати внутрішню структуру картельних домовленостей. Такий підхід відповідає європейським стандартам антикартельної політики та розглядається як ключовий елемент ефективного державного контролю у сфері захисту конкуренції.

У відповідності до абз. 2 ч. 2 ст. 52 Закону України «Про захист економічної конкуренції», органи Антимонопольного комітету України накладають штрафи на об'єднання, суб'єктів господарювання за вчинення антиконкурентних узгоджених дій у розмірі до десяти відсотків доходу (виручки) суб'єкта господарювання від реалізації продукції (товарів, робіт, послуг) за останній звітний рік, що передував року, в якому накладається штраф. У разі наявності незаконно одержаного прибутку, який перевищує десять відсотків зазначеного доходу (виручки), штраф накладається у розмірі, що не перевищує потрійного розміру незаконно одержаного прибутку [1].

Розпорядженням від 14 грудня 2023 року № 22-рп Антимонопольного комітету України затверджено Порядок визначення розміру штрафу, що накладається за порушення законодавства про захист економічної конкуренції (далі – Порядок). У цьому правовому акті зазначені основні підходи до визначення розміру штрафу. Зокрема вказано, що обставини, які беруться до уваги під час визначення розміру штрафу, встановлюються: службовцями Комітету, його територіальних відділень, які здійснюють збирання та аналіз доказів у справі, до прийняття рішення у справі органом Комітету на підставі будь-якої інформації, яка є належною та достовірною (підтвердженою/ засвідченою органами державної влади або може бути перевірена) [2].

Прийняття Порядку вирішило одну з проблем – визначило чіткий алгоритм розрахування розміру штрафу за вчинення антиконкурентних узгоджених

дій. Проте, законодавець досі надає органам АМКУ значну свободу розсуду, зокрема, при визначенні базового розміру штрафу використовується словосполучення – «до 15 чи 30% доходу (виручки) від реалі зації продукції (товарів, робіт, послуг)». При цьому відсутнє пояснення, за яких умов базо вий розмір штрафу може дійти до 30%, а коли до 11–29%. За таких обставин досі існує вірогідність спроб впливу на уповноважених пред ставників антимонопольних органів із метою зменшення розміру призначуваних штрафних санкцій. Тому варто внести відповідні зміни до законодавства. Також доцільно більш детально прописати механізм зменшення базового розміру штрафу за вчинення антиконкурентних узгоджених дій за наявності, передбачених Порядком обставин, у тому числі, вказати на який відсоток він змен шиться. Це сприятиме співпраці суб'єкта господарювання, який вчинив або погодився вчинити антиконкурентні узгоджені дії з органами Антимонопольного комітету України. [3].

У цьому контексті особливого значення набувають механізми пом'якшення відповідальності, насамперед програми звільнення або зменшення штрафів (leniency). Як слушно зазначає Т. І. Швидка, програма пом'якшення відповідальності за вчинення правопорушення є вельми ефективною у виявленні змов, які за інших обставин могли б залишитися нерозкритими. Її головна функція – дестабілізувати діяльність існуючих картелів та завадити іншим потенційним правопорушникам вдаватися до картельних домовленостей. Законодавці керувались тим, що на практиці дуже складно виявити таємні антиконкурентні узгоджені дії та довести їх існування. Вдаючись до пом'якшення відповідальності, можна отримати зізнання, прямі докази про інших учасників та змогу отримати інші додаткові докази [4].

Нормативне закріплення зазначеного підходу в Україні здійснено шляхом ухвалення Розпорядження Антимонопольного комітету України № 19-рп від 30 листопада 2023 року, яким затверджено Порядок звільнення від відповідальності за вчинення порушення законодавства про захист економічної конкуренції у формі антиконкурентних узгоджених дій [5]. Запровадження цього підзаконного нормативно-правового акта має системне значення для розвитку національної антикартельної політики, оскільки вперше на рівні детально врегульованої процедури закріплює механізм процесуального заохочення суб'єктів господарювання до добровільного розкриття картельних змов.

Зазначений Порядок інституціоналізує leniency policy як складову комплексної моделі відповідальності, орієнтованої не лише на покарання, а й на підвищення ефективності виявлення та доведення антиконкурентних узгоджених дій. Така трансформація дозволяє не лише підвищити рівень викриття картельних змов, а й сформувати для учасників ринку раціональні правові стимули до відмови від антиконкурентної поведінки та співпраці з антимонопольними органами, що в довгостроковій перспективі сприяє зміцненню конкурентного середовища та правової визначеності у сфері господарювання.

Водночас ефективність застосування програм пом'якшення відповідальності в Україні залишається обмеженою. Серед основних стримуючих факторів слід виокремити недостатню правову визначеність наслідків співпраці з Антимонопольним комітетом України, ризики паралельної цивільно-правової або кримінальної відповідальності, а також обмежену довіру бізнесу до стабільності та передбачуваності правозастосовної практики.

Поряд із механізмами пом'якшення відповідальності законодавство передбачає застосування обтяжуючих обставин, які впливають на визначення розміру штрафу та загальну оцінку антиконкурентних узгоджених дій. До таких обставин належать, зокрема, повторність порушень, ініціативна або координуюча роль суб'єкта у змові, тривалість антиконкурентної поведінки, а також перешкоджання проведенню розслідування.

Застосування обтяжуючих обставин виконує важливу превентивну функцію, оскільки дозволяє диференціювати відповідальність між учасниками змови та запобігати формуванню стійких антиконкурентних практик. Водночас відсутність уніфікованих підходів до їх оцінки може призводити до нерівномірності правозастосування та зниження довіри до рішень антимонопольного органу.

Крім того, що до обставин, які обтяжують відповідальність, слід віднести сукупність правопорушень. Враховуючи масштабність правопорушення, згідно із Методикою визначення територіальних меж, якими можуть бути як територія країни, регіону, району, міста, або глобальна територія всесвіту, необхідно і передбачати розмір штрафу або іншого виду відповідальності. Коли мова йде про прояви недобросовісної конкуренції, наприклад, про недобросовісну рекламу, треба виходити з того, що одна справа, якщо поширення цієї реклами не має великої популярності або масштабності, і зовсім інша, якщо вона стосується великої міжнародної або національної компанії, через дії якої було завдано шкоди іншим суб'єктам або споживачам. Такі ж випадки можуть бути і щодо дискримінації суб'єктів господарювання, введення споживачів в оману тощо. Особливо небезпечними можуть стати масштабні правопорушення щодо розголошення або використання комерційної таємниці тощо. З огляду на це, на думку Т.І. Швидкої, статті Кодексу України про конкурентні правопорушення мають закріплювати склад кожного правопорушення й види відповідальності, передбачаючи обставини пом'якшення, обтяження або умови звільнення від відповідальності. Для правильної кваліфікації правопорушення й визначення підстави для притягнення до відповідальності необхідно встановити його склад, що являє собою об'єкт, об'єктивну сторону, суб'єкт і суб'єктивну сторону [6].

У зазначеному контексті особливого значення набуває механізм врегулювання справ (settlement) як інструмент альтернативного завершення прова-

джень у сфері захисту економічної конкуренції, нормативно закріплений у статті 46¹ Закону України «Про захист економічної конкуренції» [1] та конкретизований у Порядку врегулювання у справах про антиконкурентні узгоджені дії та зловживання монопольним (домінуючим) становищем на ринку, затвердженому розпорядженням Антимонопольного комітету України від 30 листопада 2023 року № 18-рп [7]. Запровадження цього інституту засвідчує послідовну імплементацію в національне конкурентне право сучасних європейських підходів до правозастосування, орієнтованих на баланс між ефективністю контролю та процесуальною економією.

Затверджений Порядок формує цілісну та структуровану процесуальну модель settlement, що передбачає добровільне визнання суб'єктом господарювання факту вчинення порушення законодавства про захист економічної конкуренції, припинення антиконкурентної поведінки, надання зобов'язань щодо усунення її причин і наслідків, а також укладення письмової угоди з органом Антимонопольного комітету України. Водночас законодавець чітко окреслив межі допустимості застосування цього механізму, виключивши можливість його використання у разі повторних порушень, а також у ситуаціях, коли антиконкурентні дії за своєю природою не можуть бути припинені або їх наслідки — усунуті. Такий підхід спрямований на запобігання зловживанню процедурою врегулювання та збереження її регулятивного потенціалу.

Процедура settlement у системі національного конкурентного права виконує подвійну функціональну роль. З одного боку, вона сприяє оптимізації строків розгляду справ, зменшенню процесуальних витрат і адміністративного навантаження на Антимонопольний комітет України, що набуває особливої актуальності в умовах воєнного стану та обмежених інституційних ресурсів. З іншого боку, цей механізм забезпечує реалізацію превентивної та регулятивної функцій антимонопольного законодавства, стимулюючи суб'єктів господарювання до добровільного припинення порушень, корекції ринкової поведінки та впровадження внутрішніх комплаєнс-механізмів.

Водночас слід констатувати, що практика застосування механізму settlement в Україні перебуває на початковій стадії інституційного становлення, що зумовлює наявність низки нормативних і правозастосовних викликів. В умовах воєнного стану ці ризики посилюються через підвищену чутливість окремих товарних ринків, обмеженість ресурсів органів державної влади та необхідність оперативного реагування на порушення. За таких обставин існує небезпека формалізації процедури врегулювання та її редукції до інструменту суто фінансової оптимізації відповідальності без досягнення реальних змін у конкурентній поведінці суб'єктів господарювання. У разі втрати регулятивної та превентивної складових settlement ризикує трансформуватися з механізму впливу на ринкову поведінку у технічний спосіб зменшення санкцій, що суперечить його доктринальному призначенню та цілям антикартельної політики.

Нормативне закріплення детального порядку визначення розміру штрафів, а також процедур звільнення від відповідальності (leniency) і врегулювання справ (settlement) засвідчує поступову імплементацію в національне конкурентне право європейських стандартів антикартельної політики. Водночас збереження значного обсягу дискреційних повноважень органів Антимонопольного комітету України при визначенні базового розміру штрафу та коригуванні його з урахуванням пом'якшуючих і обтяжуючих обставин об'єктивно породжує ризики правової невизначеності, нерівномірності правозастосування та зниження рівня довіри бізнесу до антимонопольного контролю.

Програми пом'якшення відповідальності та механізм врегулювання справ мають істотний потенціал як інструменти превентивного впливу, проте їх ефективність значною мірою залежить від передбачуваності правових наслідків співпраці з антимонопольним органом, належного нормативного балансування між публічними та приватними інтересами, а також формування сталої правозастосовної практики. В умовах воєнного стану ці виклики набувають особливої гостроти, оскільки підвищується соціально-економічна чутливість окремих ринків і зростає потреба у швидких, але водночас легітимних та обґрунтованих рішеннях.

Висновки. Проведене дослідження дозволяє дійти висновку, що механізми пом'якшення та обтяження відповідальності за участь в антиконкурентних узгоджених діях доцільно розглядати не як допоміжні елементи санкційної політики, а як самостійні інструменти формування та коригування конкурентної поведінки суб'єктів господарювання. Їх ефективність визначається не стільки рівнем штрафних санкцій, скільки здатністю правозастосовної системи створювати раціональні стимули до дотримання правил добросовісної конкуренції.

Обґрунтовано, що програми пом'якшення відповідальності (leniency policy) виконують комплексну функцію: з одного боку, вони сприяють спрощенню доказування антиконкурентних узгоджених дій, а з іншого — впливають на внутрішню логіку функціонування картельних змов, підвищуючи ймовірність їх саморозкриття. За таких умов результативність leniency policy безпосередньо залежить від рівня нормативної визначеності, інституційної стабільності антимонопольного органу та узгодженості механізмів пом'якшення з іншими формами юридичної відповідальності.

Встановлено, що застосування обтяжуючих обставин і додаткових обмежувальних заходів має не лише каральний, а й сигнальний характер, формуючи для учасників ринку чіткі орієнтири щодо меж допустимої конкурентної поведінки. Водночас їх використання потребує виваженого підходу, оскільки надмірна концентрація на обмежувальних заходах без належного врахування економічних наслідків може негативно позначатися на рівні конкуренції.

Водночас важливим елементом сучасної моделі відповідальності за антиконкурентні узгоджені дії є механізм врегулювання справ (settlement), який

посилює функціональну гнучкість антимонопольного правозастосування. Його значення полягає у можливості поєднання процесуальної економії з досягненням регулятивних цілей конкурентного права шляхом добровільного визнання порушення, припинення антиконкурентної поведінки та прийняття суб'єктом господарювання зобов'язань щодо усунення її наслідків. За своєю правовою природою settlement доповнює механізми пом'якшення відповідальності, формуючи договірно-стимулюючий вимір антикартельної політики, який орієнтований не лише на санкціонування минулої поведінки, а й на корекцію майбутніх ринкових стратегій. Ефективність цього інституту, однак, безпосередньо залежить від збереження балансу між дискрецією антимонопольного органу та чіткістю нормативних критеріїв його застосування, що є необхідною умовою довіри бізнесу та стабільності конкурентного середовища.

Зроблено висновок, що однією з ключових проблем сучасної правозастосовної практики є відсутність чіткої, послідовної та передбачуваної моделі співвідношення пом'якшуючих і обтяжуючих механізмів відповідальності. Нерівномірність їх застосування знижує рівень довіри суб'єктів господарювання до органів конкуренційного контролю та зменшує мотивацію до добровільної співпраці з антимонопольними органами.

Узагальнюючи результати дослідження, обґрунтовано доцільність формування цілісного підходу до відповідальності за антиконкурентні узгоджені дії, який би поєднував превентивну, стимулюючу та каральну складові. Такий підхід має ґрунтуватися на прозорих і зрозумілих критеріях застосування пом'якшуючих та обтяжуючих заходів, узгодженні національної антикартельної політики з європейськими стандартами та посиленні аналітичної функції Антимонопольного комітету України як центрального елемента системи захисту економічної конкуренції.

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MEDICAL SCIENCES

VITAMIN D SUPPLEMENTATION AND SLEEP: REVIEW

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Abstract

Background: Vitamin D deficiency is associated with sleep disorders and poor sleep quality. Whether vitamin D supplementation (VDS) helps resolve these problems remains unclear. Objective: To systematically review the effect of VDS on sleep quantity, quality, and disorders, and perform a meta-analysis of available data. Methods: The reporting of this review followed the PRISMA statement. VDS human interventions studies that reported on sleep quality, quantity, or disorders were included. Medline, CINAHL, EMBASE, PsycInfo, the Cochrane Library, Clinicaltrials.gov, and the ICTRP were searched, in addition to the references of the included articles and previous relevant reviews, without language or time restrictions. Included studies were critically appraised, findings were narratively synthesized, and a meta-analysis was conducted. Furthermore, the overall certainty of the evidence was assessed. Results: A total of 19 studies were included (13 randomized controlled trials (RCTs), 1 opportunistic addition to an RCT, 4 pre–post studies, and 1 pre–post study analyzed as a case series); 3 RCTs were meta-analyses. The risk of bias was generally low. Pre–post studies showed a significant improvement in sleep quality with VDS. Similarly, the results of the meta-analysis revealed a statistically significant decrease in the Pittsburgh Sleep Quality Index with VDS compared with placebo (mean difference, −2.33 (95% CI, −3.09, −1.57); $p < 0.001$; $I^2 = 0\%$), with a moderate certainty of evidence. The results regarding the effect of VDS on sleep-related impairment, difficulty, and disorders, as well as sleepiness and restless legs syndrome, were not unanimous. Conclusions: VDS is promising in improving sleep quality; however, its effect on sleep quantity and disorders needs to be further investigated.

Keywords: vitamin D, sleep.

INTRODUCTION

Inadequate sleep is a common public health problem of significant personal and societal burden (1). Sleep disorders such as insomnia, obstructive sleep apnea (OSA), excessive daytime sleepiness (EDS) and fatigue, sleep deprivation, and restless legs syndrome (RLS) are increasingly being diagnosed in clinical practice (2). It is estimated that 59% of young adults suffer from a sleep disorder and do not get enough sleep (3) and only 36% of this population reports being free of sleep disturbances (4). Inadequate sleep is an underappreciated determinant of health (5,6) and can lead to short-term and long-term consequences. In the short run, inadequate sleep may result in cognitive and motor performance impairments, which can lead to decreased quality of life and reduced productivity (7,8) . In the longer term, cumulative sleep deprivation can serve as a factor in the development and exacerbation of cardiovascular and metabolic diseases, cancer, diabetes mellitus, gastrointestinal disorders, and mental illnesses. Thus, the economic burden of inadequate sleep is substantial, warranting urgent investment in health measures to address this issue (1).

Low vitamin D status is a prevalent condition that has been linked to a wide range of adverse health outcomes (10,11). Growing evidence has demonstrated that vitamin D has a role in sleep regulation (12). Specifically, vitamin D deficiency (VDD) can increase risk of sleep disorders and is associated with sleep difficulties, shorter sleep duration, and nocturnal awakenings in children and adults (13,14,15). The exact mechanisms by which vitamin D regulates sleep are still far from being elucidated. Plausible theories include the presence of vitamin D receptors on areas of the brainstem that are known to be pacemaker cells playing an important role in sleep regulation (16,17), in addition to the potential role of vitamin D in regulating melatonin, the "sleep hormone" (18).

Hence, it is plausible that vitamin D supplementation (VDS) might have a positive effect on sleep disorders, including decreased sleep latency, improved sleep efficiency, and longer sleep duration. Preventing and managing sleep disorders or correcting them by VDS is of public health relevance, given the low cost of this intervention and its effectiveness in other therapeutic areas. Given the lack of conclusive evidence in this regard, we aim to systematically review the available literature on the effect of VDS on sleep quantity, quality,

and sleep disorders, and perform a meta-analysis of the available data.

MATERIALS AND METHODS

Criteria for Study Inclusion

Interventional studies, whether controlled or not, conducted on individuals not having diseases or receiving medication known to influence vitamin D metabolism, such as chronic kidney disease or liver disease, with or without sleep disturbances, including vitamin D supplementation in any form, dose, or frequency as intervention, and reporting on the prevalence or severity of sleep disorders (19), such as insomnia disorders, sleep-related breathing disorders, central disorders of hypersomnolence, circadian rhythm sleep–wake disorders, parasomnias, and sleep-related movement disorders, or sleep quantity or quality, were included.

All studies extending supplementation for a minimum of 4 weeks were included in this review to ensure adequate time for the intervention to produce an effect. In addition, controlled studies involving a placebo, or a lower dose, or different form of vitamin D were included. Finally, controlled studies including a co-intervention were included if both arms of the study received the same co-intervention.

Eligible studies were those written in any language, irrespective of publication date (i.e., no language or time limit).

Exclusion criteria included non-original studies (e.g., case reports, case series, editorials, and reviews) and studies conducted on participants with conditions (e.g., chronic kidney disease) or on medications that might have an effect on vitamin D metabolism (e.g., phenytoin, phenobarbital, carbamazepine, and rifampin). Finally, studies evaluating the association between vitamin D status (hypo or hypervitaminosis D) and sleep were not included.

Search Strategy

The author searched Medline via Ovid, the Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCO, EMBASE via Ovid, APA PsycInfo via Ovid, the Cochrane Library, Clinicaltrials.gov, and the International Clinical Trials Registry Platform (ICTRP). Vitamin D supplementation and sleep were the key concepts followed in the search strategy: for each concept, Medical Subject Headings (MeSH) and keywords were recorded, whereby search terms included vitamin D, cholecalciferol, ergocalciferol or calcidol, combined with sleep or insomnia. The author did not apply any language or publication date restrictions to the search. The author also hand searched the reference lists of included articles and previous relevant reviews for eligible studies.

Study Selection

Studies meeting the inclusion criteria previously specified were identified by screening titles and/or abstracts from electronic scientific databases via Endnote, version X6. Full texts of potentially eligible studies were retrieved. Finally, records in the grey literature search zone were further assessed for eligibility of inclusion.

Data Extraction

For all eligible studies, data related to the features of the study, population groups, interventions given (type, form, and the dose of vitamin D in experimental groups, comparator, and duration), outcomes, and main findings were extracted and recorded in a data extraction form. When reported as nmol/L, the author converted serum 25OHD to ng/mL by dividing by a factor of 2.496. The author contacted the authors of some included studies to obtain additional data, when they were not reported in the published studies.

Quality Assessment

The Cochrane criteria (sequence generation, allocation concealment, blinding of participants and outcome assessors, incomplete outcome data, and selective outcome reporting) were used as the tool to assess the risk of bias of RCTs included in this review (20). Furthermore, a modified version of the Cochrane Risk of Bias tool (21) (eligibility criteria, measurement of exposure and outcome, control confounding, and follow-up) was used to assess the risk of bias of non-randomized studies. Potential sources of bias for both RCTs and non-randomized studies were graded as low, high, or unclear risk.

Data Synthesis

A narrative composite of the study findings was provided when a meta-analysis was not feasible. Furthermore, author-recorded features of the study, population group characteristics, intervention provided, comparator, and the outcome were included in this composite.

A meta-analysis was conducted when participants, treatments, and outcomes shared similar characteristics to allow pooling. Standard meta-analyses comparing VDS with placebo were performed using RevMan version 5.4 (The Cochrane Collaboration, The Nordic Cochrane Centre). A random-effects model was used for the analysis of more than two studies. The results were reported as the mean difference with 95% confidence intervals. The I^2 statistic was used to assess heterogeneity among different studies.

Quality of Reporting

The Preferred Reporting Items for Systematic reviews and Meta-Analyses literature search extension (PRISMA-S) checklist and the PRISMA statement were followed for the literature search component (22), and the reporting of this systematic review (23).

RESULTS

Search Results

Out of the 19,051 screened records, 19 studies were included in this systematic review. Out of these studies, thirteen were RCTs (24-36), one was an opportunistic addition to an established randomized, double-blind, placebo-controlled trial (37), four were pre–post studies (38-41), and one was a self-controlled before–after trial, analyzed retrospectively as a case series (42).

Three out of thirteen RCTs generated data that could be combined in the meta-analysis.

Characteristics of Included Studies

Six of the studies were conducted in Iran (25, 27,30,31,34,39), five in the USA (28, 29,32,33,42), one in Ireland (26), one in New Zealand (37), one in KSA (35), one in China (36), one in Turkey (40), and one in the Netherlands (24). The number of participants varied from 5 (31) to 18,353 (32). Two studies were conducted in the pediatric population: children with Autism Spectrum Disorder (40) and ADHD (31), one study was con-

ducted on overweight postmenopausal women (28), another in elderly women (39), and one on community-dwelling older people (24). One study was conducted in patients receiving maintenance methadone treatment (25), one in active-duty warfighters (29), one on veterans with multiple areas of chronic pain and low serum 25(OH)D (42), one on adult patients with urticarial (33), one on fibromyalgia syndrome patients (30), one in patients with chronic low back pain (41), and one on patients with depression with tied anxiety symptoms (36). Finally, one study was conducted on adults with OSA (26), one on adults with sleep disorders (27), two in patients with RLS (35,38), and one on adults with vitamin D deficiency, abdominal obesity, and symptoms of insomnia (34).

In the majority of the studies, the intervention consisted of vitamin D3 supplementation (24, 26,27,28,29,32,33,34,35,37,38,42) , two used vitamin D2 supplementation (40,42), and the form of vitamin D was unclear in six trials (25,30,31,36,39,41). Only Sharifan et al. (34) assessed VDS in the form of fortified low-fat milk or low-fat yogurt. The duration of supplementation ranged from 8 weeks (27,30,31,39,41) to a median of 5.3 years (32). The average daily dose of VDS ranged from 1000 IU (29,39) to 7142.85 IU (30,35,42). When reported, compliance with VDS was high in all studies. The majority of the studies were placebo controlled (24,25,26,27,28,30,31,32,35,36,37). In two studies, the comparator was no supplementation (29,39); in one study, it was a lower dose of vitamin D (33); in one study, it was either low-fat milk or yogurt (34). The most assessed outcome was sleep quality, mainly using the Pittsburgh Sleep Quality Index (PSQI) (25,27,28,30,39,41,42).

Sleep Quality

The pre–post studies by Huang et al. (42), Eshaghi et al. (39), and Maheshwari et al. [41] investigated the effect of VDS on sleep quality assessed by the PSQI. All three trials showed a significant improvement in overall sleep quality with VDS. However, the three trials were heterogeneous and did not contain ample information allowing pooling; hence, performing a meta-analysis of their results was impossible.

The four RCTs conducted by Ghaderi et al. (25), Majid et al. (27), Mason et al. (28), and Mirzaei et al. (30) explored the effect of VDS on sleep quality assessed by the PSQI. Only three (25,27,30) provided information and had similar characteristics to allow pooling, whereas the study by Mason et al. (28) did not report on numerical outcomes, and therefore was not included in the meta-analysis. This study showed no significant change in overall sleep quality with VDS and a deterioration in total PSQI among women who repleted their vitamin D levels, concluding that VDS of 2000 IU/d may result in overall worse sleep quality for postmenopausal women with low circulating vitamin D undergoing weight loss.

The three studies included patients undergoing maintenance methadone treatment (25), people with a PSQI $\geq$ 5 (27), and fibromyalgia syndrome patients (30). The duration of VDS was short (8 (27, 30) to 12 weeks (25)), and the dose was either 3571.42 (25, 27) or 7142.85 IU (30). A statistically significant decrease in the PSQI in the group receiving VDS as compared with placebo was shown by the meta-analysis (mean difference, −2.33 (95% CI, −3.09, −1.57); p <0.001).

Other Outcomes

Disturbed sleeping

The only pre–post study (40) investigating sleep habits and disorders in children with ASD showed that VDS may be beneficial in these patients, as well as healthy individuals with sleep disturbances.

As for RCTs, the effects of VDS on sleep-related impairment, sleep difficulty, and sleep disorders were assessed by McCarthy et al. (29) , Okereke et al. (32), and Zhu et al. (36), respectively; the results were not unanimous. While McCarthy et al. (29) showed a statistically significant improvement in sleep-related impairment with VDS, Okereke et al. (32) and Zhu et al. (36) did not report on such findings. In both RCTs, there were non-significant differences in likelihood of sleep problems with VDS compared with placebo after controlling for confounding variables).

Sleepiness

Two RCTs assessed the effect of VDS on sleepiness using different tools (26, 34). The study of Kerley et al. (26), which was conducted on patients with OSA, did not report any difference in sleepiness between the group receiving VDS and those receiving placebo. In contrast, the study by Sharifan et al. (34), which was conducted on patients with insomnia, showed a beneficial effect of vitamin D3-fortified low-fat milk on insomnia symptoms compared with unfortified milk. No effect was detected with vitamin D3-fortified low-fat yogurt compared with unfortified one.

RLS

The pre–post study conducted by Arico et al. (38) found that long-term VDS (6 months) decreased RLS severity in a small population (5 patients). In contrast, the RCT by Wali et al. (35) found no effect of VDS on severity of RLS compared with placebo.

Sleep Problems as Adverse Events of VDS

Sleep problems as an adverse event of VDS were assessed in the two RCTs conducted by Mohammadpour et al. (31), and de Koning et al. (24). Both studies showed no significant difference in sleep problems with VDS versus placebo in children with ADHD or community-dwelling people with depressive symptoms, respectively.

CONCLUCIONS

In conclusion, the evidence presented in this review suggests a beneficial role of VDS in enhancing sleep quality. These results remain to be interpreted with caution given the limited number of included RTCs and their relatively small sample size. Nevertheless, the positive effects of such supplementation could be considered in clinical practice, especially in the context of beneficial skeletal (56) and pleiotropic extraskeletal effects (57, 58) of vitamin D, as well as the relatively limited cost of VDS. As we could not find enough studies assessing the effect of VDS on sleep disorders, OSA, sleepiness, and RLS, this remains to be explored in future adequately powered, high-quality RCTs.

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IMPACT OF VITAMIN D ON PHYSICAL EFFICIENCY AND EXERCISE PERFORMANCE—A REVIEW

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Abstract

Vitamin D deficiency amongst athletes and the general population seems to be a prominent problem. The most recognized role of vitamin D is its regulation of calcium homeostasis; there is a strong relationship between vitamin D and bone health. Moreover, its concentrations are associated with muscle function and immune response in both the general and athletic populations. Vitamin D level is strongly connected with the presence of VDRs (vitamin D receptors) in most human extraskeletal cells. Expression of multiple myogenic transcription factors enhancing muscle cell proliferation and differentiation is caused by an exposure of skeletal muscles to vitamin D. The aim of this review is to summarize current understanding of the significance of vitamin D on exercise performance and physical efficiency, as well to analyze the impact of vitamin D on multiple potential mechanisms. More high-quality research studies, considering free 25(OH)D as a better marker of vitamin D status, the baseline level of 25(OH)D and multiple pathways of vitamin D acting and usage in athletes are required.

Keywords: 25(OH)D, VDR, VDBP, athlete, physical efficiency, exercise performance, vitamin D deficiency.

INTRODUCTION

Vitamin D is a group of steroid compounds demonstrating the same biological activity, mainly associated with affecting calcium phosphate economy. It occurs in nature in the forms of vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). Vitamin D2 is produced by fungi and yeast by UVB-exposure of ergosterol (provitamin D2), therefore, ergocalciferol is found in sun-dried mushroom products and in plant-based products (as a result of contamination with fungi) (1, 2). Accordingly, vitamin D2 is generally known as a plant form of vitamin D, whereas vitamin D3 is produced by UVB-exposure of 7-dehydrocholesterol (provitamin D3) in the skin of many vertebrate animals, including humans. Cholecalciferol can be provided by consuming animal products like fatty fish (mackerel, salmon, sardines), fish oil, eggs and liver or, in smaller amounts, meat, dairy products, offal and poultry (3). Nevertheless, over 90% of vitamin D in the human body is formed in the skin tissue influenced by sunlight. Provitamin D (7-dehydrocholesterol) is converted under ultraviolet B (UVB) rays to previtamin D3 and ultimately to vitamin D3 (4). It is certain that 25(OH)D can be increased by vitamin D supplementation, proper nutrition and exposing uncovered skin to sun radiation (sun angle should be over 30°) (6). There are many other factors that decrease the level of vitamin D, such as obesity (adiposity may decrease bioavailability of 25-hydroxyvitamin D) (7), liver failure, senectitude, darker skin tone or sunscreen use (8,9,10). Smoking cigarettes also has a significant negative influence on the level of vitamin D (11). Beyond modifiable factors there are dimensions such as genetic determinants, individual variations (12) or age that are not modifiable (13). The relationship between gender and vitamin D deficiency or 25(OH)D level is inconsistent and elaborate in non-athletes. Verdoia et al. observed significantly lower 25(OH)D levels in females (female 14.5 ± 10.9 ng/mL vs. male 15.9 ± 9.5 ng/mL, $p = 0.007$), which might be strongly related to the older age of women participating in the study comparing to men ($p < 0.001$). Moreover, a higher rate of vitamin D deficiency occurred especially in post-menopausal women. (14). On the contrary, the study of AlQuainz et al. identified a higher prevalence of vitamin D deficiency among males when compared to females (72.0% ($n = 695$) vs. 64.0% ($n = 1191$)) (15). Likewise, the study of Johnson et al., conducted on morbidly obese patients, showed that male patients had significantly lower mean 25(OH)D concentrations than female patients (50.0 ± 22.0 nmol/L versus 53.6 ± 22.4 nmol/L ($p = 0.001$)) and a higher rate of vitamin D deficiency than women (56% vs. 47%; $p < 0.001$) (16). Gender differences can be related with both known (for example, more men smoke cigarettes and are less likely than women to avoid high-fat foods, women wear hijabs covering the whole body) and unknown habits. The differences by sex may be due to variations in body fat percentage and body size (17). The decrease in vitamin D bioavailability is thought to be due to sequestration of vitamin D in adipose tissue after cutaneous synthesis or dietary intake, although the exact mechanism is not yet known. However, the study of Halliday et al. showed no difference in vitamin D status depending on sex in athletes ($p = 0.10$). Any cor-

relations between body mass, BMI or body fat percentage adjusted by sex were also not found in athletes. The reason for a lack of a significant correlation between vitamin D status and adiposity in this study is most likely explained by the reduced body fat range of the athlete population. Moreover, different sport disciplines were studied in relation to male and female athletes (18).

Vitamin D insufficiency seems to be a very prominent problem amongst athletes and the general population (19, 20). The evidence available suggests that there is a cause for concern regarding the vitamin D concentration of athletes depending on sun exposure. The results of a huge meta-analysis of 23 studies with 2313 athletes demonstrated that 56% of them had vitamin D inadequacy. Vitamin D insufficiency significantly varied by latitude, also, it was higher during winter and at the beginning of the spring season (21) and for those athletes doing indoor sport activities (22). The difference between outdoor and indoor athletes is noticeable in the study of Aydin et al., which showed the prevalence of vitamin D deficiency in 59% of outdoor athletes and 64% of indoor athletes. The study was conducted during winter season [4]. Peeling et al. found significantly lower vitamin D status in indoor (90 ± 28 nmol/L) compared to outdoor (131 ± 35 nmol/L) athletes ($p = 0.0001$). Considering the predominant training environment during the summer season, 50% trained predominately indoors (31 gymnastics, 5 diving) and 30.6% trained predominately outdoors (10 sailing, 7 field hockey, 3 athletics, 2 rowing) (23). Halliday et al. documented that 25(OH)D concentrations changed across time ($p = 0.001$) and averaged 49.0 ± 16.6, 30.5 ± 9.4, and 41.9 ± 14.6 ng/mL in the fall, winter, and spring, respectively, in a group of 41 collegiate athletes (12 indoor (wrestling, swimming, basketball) and 29 outdoor athletes (football, soccer, cross-country or track and field, and cheerleading/dance)). Vitamin D levels were significantly higher in outdoor compared with indoor athletes in the fall (53.1 ± 17.4 vs. 39.3 ± 8.9 ng/mL, $p = 0.013$); in the winter or spring, vitamin D concentrations were higher in outdoor athletes, but these differences were not statistically significant. Of the athletes studied, 75.6% in the fall, 15.2% in the winter, and 36.0% in the spring had optimal 25(OH)D status (40 ng/mL was the cut-off for optimal status). Neither total vitamin D intake nor intake from food alone differed across time or with sex or training location ($p < 0.05$) (18).

METABOLISM OF VITAMIN D AND MECHANISMS OF VITAMIN D RECEPTOR

The activity of vitamin D is highly connected with cytochrome P450 enzymes which are responsible for both activation (25-hydroxylase, 1α-hydroxylase) and deactivation (24-hydroxylase) of vitamin D. Firstly, 25(OH)D is produced in the liver, from D2 or D3 with the contribution of CYP2R1 (25-hydroxylase), and then in the kidneys, the biologically active form of vitamin D— 1,25(OH)2D—is synthesized by CYP27B1 (1α-hydroxylase) from 25(OH)D. Inactivation of vitamin D goes gradually by 24-hydroxylase that forms inactive metabolites 24,25-dihydroxyvitamin D and 1,24,25-trihydroxyvitamin D from 25(OH)D and 1,25(OH)2D, respectively. In the end, CYP3A4 degrades them (24). The enzymes mentioned above are magnesium-dependent; optimal magnesium concentration, depending on baseline level of 25(OH)D, can be helpful to reaching proper 25(OH)D target concentration (25).

The biological function of vitamin D, in principle 1,25-dihydroxyvitamin D—the active metabolite—is unspecifically mediated by binding to a single vitamin D receptor (VDR) that is expressed in several tissues (26,27). Moreover, direct influence of 1,25(OH)2D is also possible through specific plasma membrane receptors (28).

A VDR consists of three main domains: the C-domain that binds DNA, the E-domain that connects with a ligand and the activating F-domain. The vitamin D receptor is closely connected to RXR (retinoic acid receptor); the 5′ arm of the nucleotide sequence of VDRE acts with RXR, and for VDR, it is the 3′ arm. As it is a ligand-dependent transcription factor, it binds VDR and RXR along with some other proteins and activators (SARC1-3 and DRIP205), creating a transcription complex at the VDREs so the phosphorylation is initiated (29).

It seems to be significant to mention the vitamin D-binding protein (VDBP) which is produced by hepatic parenchymal cells' glycoprotein; its main function is linking almost 90% of 25(OH)D and 1,25-dihydroxyvitamin D3 circulating in serum. Out of the total 25(OH)D, albumin binds approximately 10% and less than 1% remains free (albumin-bound and "free" are the only bioavailable forms). Black men have lower levels of VDBP than white men, having lower mean concentration of total serum 25(OH)D at the same time (Black 25.0 ± 14.7 vs. White 37.4 ± 14.0; $p < 0.001$) (30,31).

VITAMIN D IN SPORT PERFORMANCE

Due to vitamin D insufficiency in the population, many studies undertake the topic of correlation between vitamin D insufficiency and impaired sport performance, defined as skeletal muscle function. Vitamin D is one of the most regularly used dietary supplements amongst athletes worldwide and is the number one supplement taken by athletes with a physical impairment (32, 33). Close et al. found a significantly positive correlation between vitamin D3 supplementation (5000 IU per day for 8-weeks) and the improvement of musculoskeletal performance, especially in vertical jump height and 10-m sprint times. The study was a placebo-controlled trial conducted on 61 male athletes coming from different sports (soccer, rugby, flat and hunt jockeys) and 30 controls who were apparently healthy non-athletic individuals. It was found that 62% of the athletes had a baseline level of total serum 25(OH)D below 50 nmol/L and also that 73% of the controls were 25(OH)D-deficient or had inadequate 25(OH)D level. Total serum 25(OH)D significantly increased from baseline in the vitamin D treated group of athletes (34).

Moreover, Książek et al. showed that there is a positive correlation between vitamin D levels and sport performance. They enrolled 25 representatives of the Polish National judo team who were in the general preparation period and were performing almost the same exercises. It was found that 80% of the athletes

were vitamin D deficient, with less than 30 ng/mL 25(OH)D in the baseline. The results of the study presented a statistically positive correlation between 25(OH)D concentration and the power of vertical jump. There was also significant correlation with left hand grip strength and total work for both the right and left lower extremities during extension (35).

Rowing is a discipline where most of the energy is supplied via aerobic metabolism similar to other endurance types of sports. There is a correlation between aerobic power and high maximum oxygen consumption (VO_2max) where the transport of oxygen plays a key role. It is coherent that improving hematological levels is a way to enhance rowers' athletic performance. Thirty-six elite male rowers were randomly separated into a control group (CG, n = 18, height 181.05 ± 3.39 cm, body mass 77.02 ± 7.55 kg) and a group supplemented with 3000 IU of vitamin D/day for eight weeks (VD3G, n = 18, height: 179.70 ± 9.07, body mass: 76.19 ± 10.07 kg). Mielgo-Ayuso et al. intended to check if vitamin D supplementation was a suitable factor appealing to hematological and iron metabolism profile. All of the athletes had baseline suboptimal 25(OH)D concentrations (26.24 ± 8.18 ng/mL) and the tests were carried out in the spring months (April–June) in Spain. Statistically, a significant increase in the serum concentration of 25(OH)D in the VD3G after 8 weeks (T2) was observed (T1 26.24 ± 8.18 ng/mL vs. T2 48.12 ± 10.88 ng/mL; $p < 0.001$). In the CG (control group) no statistically significant changes were noticed (T1 30.76 ± 6.95 ng/mL vs. T2 35.14 ± 7.96 ng/mL; p = 0.056). Significant differences in the group-by-time interaction of hemoglobin (p = 0.009), hematocrit (p = 0.019) and transferrin (p = 0.007) between the two groups through the study were observed. Moreover, in the CG, a significant decrease ($p < 0.05$) in hemoglobin during the study (T1 15.54 ± 0.88 ng/mL vs. T2 15.09 ± 0.82 ng/mL), and a significant increase ($p< 0.05$) in VD3G in transferrin levels over 8 weeks (T1: 254.22 ± 20.69 vs. 270.44 ± 20.08 mg/dL) were observed. Although, in both groups, all body composition measures (body mass, BMI, sum 4 skinfolds, fat mass and free fat mass) presented significant differences during the study ($p < 0.05$), the group-by-time interaction of them between groups did not show any significant difference ($p > 0.05$). All rowers followed the same training program (the average weekly hours of training were 15 during the study). These results show that vitamin D supplementation affects hematological parameters and can enhance aerobic power by increasing VO_2max. However, authors did not give any information as to if the rowers were at the beginning or in the middle of their training season, which would have a relevant impact on the interpretation of results. Moreover, the study group of 36 rowers divided into two groups seems to be too small and limiting (36).

Analysis of the results of Koundourakis et al.'s research on 67 Caucasian male professional soccer players of three Greek football teams showed some interesting findings that not only exposure to UVB but also reduction of training stress may have a good influence on serum vitamin D levels. Vitamin D concentration was found to be increased significantly following the six-week off-season period (47.24 ± 13.50 ng/mL) compared to baseline (34.41 ± 7.08 ng/mL) while at the same time, all measured performance parameters decreased. Moreover, the study demonstrated a significant positive linear association between 25(OH)D level and muscle strength as evaluated by squat and countermovement jumps, sprinting ability (10- and 20-m) and aerobic capacity—VO_2max—in professional soccer players. According to this study, vitamin D levels probably play a significant supportive role in sport performance (37).

The study of Jastrzębska et al. was conducted on 36 soccer players (age: 17.5 ± 0.6 years, body mass 71.3 ± 6.9 kg, BMI 22.2 ± 1.8 kg/m^2) who were members of a sports school (Poland) that educated the highly talented youth. Players were divided into two groups: the placebo one, n = 16 and the experimental one, n = 20 (which was vitamin D3 supplemented). The selection was done deliberately into homogenous groups and even the number of players of the same field position was equal. Initial 25(OH)D levels did not differ between supplemented and placebo groups (48.5 ± 8.6 vs. 47.5 ± 16.2 mmol/L, p = 0.817). In the supplemented group, the plasma 25(OH)D level increased significantly after the intervention (initial 48.5 ± 8.6 mmol/L, after intervention 106.3 ± 26.6 mmol/L, $p < 0.0001$), while in the placebo group, only non-significant changes were observed (initial 47.5 ± 16.2 mmol/L, after intervention 43.5 ± 16.7 mmol/L, p = 0.228). The following variables improved significantly compared to the placebo group: maximal running velocity (V_{max}, p = 0.017), running velocity at lactate threshold (V_{LT}, $p < 0.0001$), V_{LT}/V_{max} (p = 0.000006), maximal heart rate (p = 0.0001), physical work capacity ($p <$ 0.0001) and maximal oxygen uptake ($p < 0.0001$) (38).

In the above studies, the subjects were supplemented with daily doses of vitamin D. Wyon et al. separated 22 judo athletes into two groups and supplemented one with a one-time dose of 150,000 IU. Nevertheless, the treatment group demonstrated a significant increase in muscle strength between days 1 and 8 (p = 0.01) (39).

On the other hand, a number of published reports fail to document any statistically significant impact of increasing vitamin D level on exercise performance (30). A recent placebo-controlled double-blind study conducted on 36 top Polish young junior soccer players, aged 17.5 ± 0.6 years, did not demonstrate statistically significant difference between the placebo and the supplemented with vitamin D groups. After eight weeks of the same high-intensity soccer training activity, it was found that there was just a little positive difference in physical activity indicators (time–motion parameters and heart rate) in comparison to placebo group. Baseline level of 25-hydroxyvitamin D did not differ significantly between supplemented (48.5 ± 8.6 nmol/L) and non-supplemented groups (47.5 ± 16.2 nmol/L) (40).

Furthermore, Orysiak et al. conducted a cross-sectional study on a group of 50 adolescent male ice hockey players. They found that vitamin D insufficiency is highly prevalent in this group, nevertheless, there was no positive correlation between serum 25(OH)D concentration and isometric muscle strength,

vertical jump performance, or repeated sprint ability (RSA) after adjusting for age, training experience, fat mass, fat free mass and height. Exercise performance was evaluated using isometric strength measures of upper and lower extremities, vertical jump performance and RSA (41).

A study on 22 rugby players supplemented with 50 000 IU of cholecalciferol (equivalent to 3570 IU/day) or placebo once every two weeks over 11–12 weeks demonstrated significant increase of serum 25(OH)D concentrations in the treatment group compared to placebo ($p< 0.001$). Performance in five of the six tests, including the primary outcome variable of 30-m sprint time, did not differ between the vitamin D supplemented and placebo groups ($p > 0.05$). Only performance on the weighted reverse-grip chin up was significantly higher in players receiving vitamin D compared with placebo ($p = 0.002$) (42).

Todd et al. observed similar findings in a research on 43 Gaelic football players, who received twelve-week daily supplementation with 3000 IU of vitamin D during wintertime. The vitamin D supplementation had no significant effect on VO_2 max ($p = 0.375$), skeletal muscle and lung function, or vertical jump height when compared to the placebo group ($p= 0.797$). It also had no significant effect on left or right handgrip strength ($p = 0.146$ and $p = 0.266$, respectively). Although the concentration of 25(OH)D increased ($p = 0.006$), there was no correlation between total 25(OH)D and measures of physical performance ($p> 0.05$) (43).

SUMMARY

According to the review, it is undoubtedly important to conduct another high-quality research study. One of the main aspects that should be taken into account is important evidence suggestive that free (bioavailable) 25(OH)D can turn out to be a better marker of vitamin D status. Many researchers do not take under consideration that athletes may require an increased supply of vitamin D to fulfill muscle metabolism requirements because of potential pathways of vitamin D usage. Significant debate seems to be needed to determine and standardize a classification of vitamin D deficiency.

Summarizing the results of this review, there are many incompatible reports about correlation between vitamin D supplementation and exercise performance for athletes. It is still uncertain if vitamin D supplementation shall be definitely recommended, however it seems to give beneficial effects while incorporating the baseline level of vitamin D status in planning studies and analyzing the results.

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ЦЕЛОСТНОСТЬ НОГТЕВОЙ ПЛАСТИНЫ В ПРОЦЕССЕ СУХОГО ЭСТЕТИЧЕСКОГО МАНИКЮРА И ПЕДИКЮРА: БЕЗОПАСНАЯ ПОДГОТОВКА, НАНЕСЕНИЕ И СНЯТИЕ ГЕЛЕВЫХ ПОКРЫТИЙ

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THE INTEGRITY OF THE NAIL PLATE DURING DRY AESTHETIC MANICURE AND PEDICURE: SAFE PREPARATION, APPLICATION AND REMOVAL OF GEL COATINGS

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Аннотация

Статья посвящена сохранению целостности ногтевой пластины при сухом эстетическом маникюре и педикюре на фоне регулярного применения гелевых покрытий. Рассматривается, что повторяющийся цикл «подготовка – нанесение – снятие» при наличии технологических ошибок может приводить к накоплению микроповреждений и ухудшению состояния ногтя. Теоретическая часть опирается на представления о ногтевом аппарате, трёхслойной структуре ногтевой пластины и влиянии факторов среды, а также на данные о различиях толщины и скорости роста ногтей рук и ног. Практическая часть систематизирует требования безопасной подготовки в сухой технике, условия безопасного нанесения и принципы щадящего снятия. Итогом является профилактический протокол стандартизации услуги с контрольными точками качества, применимый для повторяющихся процедур.

Abstract

The article is devoted to maintaining the integrity of the nail plate during dry aesthetic manicure and pedicure against the background of regular use of gel coatings. It is considered that the repeated cycle of "preparation – application – removal" in the presence of technological errors can lead to the accumulation of micro-damage and deterioration of the nail. The theoretical part is based on ideas about the nail apparatus, the three-layer structure of the nail plate and the influence of environmental factors, as well as data on differences in thickness and growth rate of nails and toenails. The practical part systematizes the requirements of safe preparation in dry technique, the conditions of safe application and the principles of gentle removal. The result is a preventive protocol for standardizing the service with quality control points, applicable for repetitive procedures.

Ключевые слова: ногтевая пластина, целостность ногтя, сухой маникюр, сухой педикюр, гелевое покрытие, подготовка ногтя, полимеризация, снятие геля, профилактический протокол, стандартизация услуги, управление качеством.

Keywords: nail plate, nail integrity, dry manicure, dry pedicure, gel coating, nail preparation, polymerization, gel removal, preventive protocol, standardization of services, quality management.

Актуальность исследования

Актуальность исследования обусловлена тем, что гелевые покрытия в эстетическом маникюре и педикюре остаются одной из самых востребованных услуг, а значит, растёт доля клиентов, регулярно проходящих цикл «подготовка – нанесение – снятие» с повторением процедур. При высокой частоте обновления покрытия даже небольшие технологические ошибки способны накапливать микроповреждения и приводить к ухудшению состояния ногтевой пластины: истончению, повышенной ломкости, слоистости, дискомфорту и снижению качества носки покрытия. В этих условиях сохранение целостности ногтя становится не частной «техникой мастера», а ключевым критерием безопасности и профессионального качества услуги.

Дополнительную значимость проблеме придаёт распространение сухих техник эстетической обработки, которые ценятся за точность, скорость и аккуратность результата. Однако «сухой» формат усиливает роль правильного выбора абразивов, дозирования давления, контроля глубины обработки и соблюдения последовательности действий: отсутствует смягчающий эффект предварительного замачивания, а часть рисков смещается в сторону механической и термической нагрузки на ноготь. Практика показывает, что именно этапы подготовки и снятия чаще всего становятся источником нарушений целостности, тогда как визуально ровное покрытие может маскировать проблемы до момента снятия или следующей процедуры.

Следовательно, научно обоснованная и стандартизированная модель безопасной подготовки, нанесения и снятия гелевых покрытий является актуальной как для повышения качества услуг и снижения количества нежелательных последствий, так и для совершенствования программ обучения мастеров. Разработка четких критериев оценки состояния ногтевой пластины, протоколов выбора материалов и инструментов, а также контрольных точек качества на каждом этапе позволяет перевести безопасность из уровня субъективного опыта в систему воспроизводимых профессиональных решений.

Цель исследования

Цель данного исследования – обосновать и систематизировать безопасный цикл «подготовка – нанесение – снятие» гелевых покрытий в условиях сухого эстетического маникюра и педикюра и предложить профилактический протокол стандартизации и контроля качества, направленный на сохранение целостности ногтевой пластины.

Материалы и методы исследования

Материалами исследования послужили данные открытых дерматологических и научных источников о строении ногтевого аппарата, свойствах ногтевой пластины, факторах риска при косметических процедурах, а также справочные сведения о толщине и скорости роста ногтей и описания практик безопасной работы с абразивами, полимеризацией и растворителями.

Использованы методы теоретического анализа и обобщения литературы, сравнительного анализа этапов процедуры, выделения типовых рисков и контрольных точек, а также метод моделирования регламента услуги в виде профилактического протокола.

Результаты исследования

Ногтевая пластина является частью ногтевого аппарата и представляет собой плотную структуру из твёрдого кератина, которая формируется клетками матрикса и прочно прилежит к ногтевому ложу. В дерматологической литературе подчёркивается, что сцепление пластины с ложем обеспечивается взаимным «замком» продольных гребней и борозд, что объясняет тесную адгезию и одновременно уязвимость при травме: при нарушении этой связи возникают клинически значимые изменения (от микроповреждений до отслоения) [5].

Рисунок ниже иллюстрирует основные зоны ногтя, которые учитываются при оценке безопасности эстетических процедур.

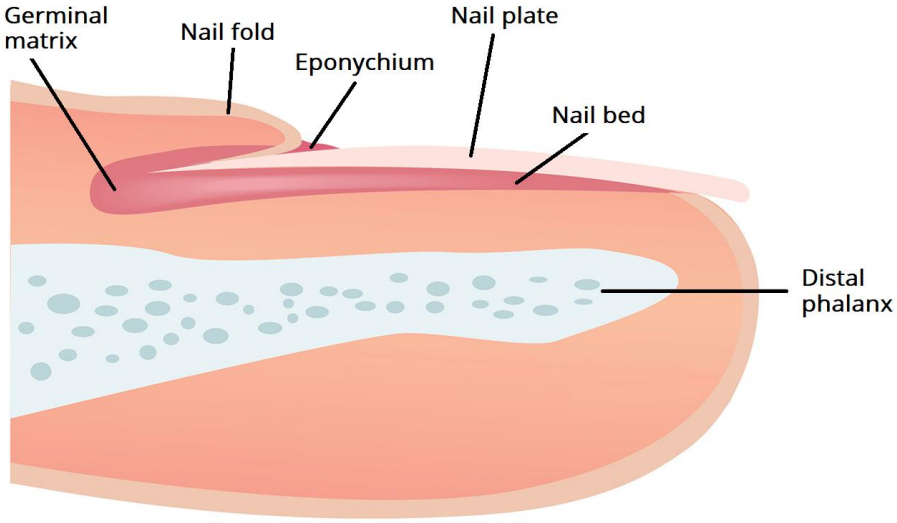

Рис. Схема ногтевого аппарата: ногтевая пластина, эпонихий (кутикула), ногтевой валик, матрикс и ногтевое ложе [4]

Структурно ногтевая пластина описывается как «ламинированная» и трёхслойная: дорсальный (поверхностный), промежуточный и вентральный (нижний) слои, различающиеся по микроструктуре и ориентации кератиновых волокон. Эта трёхслойность рассматривается как важная основа механической прочности и устойчивости к расслоению, а любые воздействия, которые «снимают» слои неравномерно, повышают риск истончения и появления продольных/поперечных борозд.

Понимание целостности ногтевой пластины в профессиональной логике опирается на измеряемые и наблюдаемые характеристики: толщину, равномерность поверхности, отсутствие ламеллярного расслоения и сохранность нормальной прозрачности, а также сохранение плотного прилегания к ногтевому ложу без признаков травматизации. При этом диапазоны нормы по толщине различаются для ногтей рук и ног и зависят от пола, а скорость роста определяет, как быстро могут «уходить» последствия повреждений при условии прекращения травмирующих факторов. В таблице 1 представлены усреднённые значения толщины и темпа роста ногтей, которые чаще всего используются в обзорной и клинической литературе.

Таблица 1

Средняя толщина и скорость роста ногтей рук и ног

Показатель	Ногти рук	Ногти ног
Средняя толщина у женщин	0,5 мм	1,38 мм
Средняя толщина у мужчин	0,6 мм	1,65 мм
Средняя скорость роста	3,47 мм/месяц	1,62 мм/месяц

Источник: [1].

Для сухого эстетического маникюра и педикюра принципиально важен водный фактор. Ногтевая пластина содержит заметную долю воды и при этом отличается относительно низким содержанием липидов, поэтому способна активно пропускать и накапливать влагу; в научных обзорах указывается, что содержание воды и водопроницаемость ногтя зависят от условий среды (включая влажность), а степень гидратации может менять конформацию кератина и, следовательно, физические свойства пластины. Отдельно подчёркивается, что повторяющиеся циклы «намокание – высыхание» ассоциируются с развитием сухости, ломкости и расслоения (ламеллярной дистрофии) в связи с изменениями межклеточных взаимодействий в пластине. В этом контексте «сухая» технология рассматривается как способ уменьшить неконтролируемые колебания гидратации во время процедуры, сместив контроль качества в сторону точности механической обработки и соблюдения технологического протокола [6].

Безопасная подготовка ногтевой пластины перед гелевым покрытием в сухой технике начинается с соблюдения гигиены и барьерных мер, потому что качество адгезии геля и сохранность целостности ногтя зависят не только от материала, но и от чистоты кожи и инструментов, а также от корректного обращения с кутикулой. В открытых рекомендациях по гигиене ногтей подчёркивается необходимость очищать и обрабатывать инструменты перед использованием, а при работе в коммерческой среде – обеспечивать стерилизацию общих инструментов; отдельно отмечается, что кутикула выполняет барьерную функцию, поэтому её повреждение повышает риск инфицирования [2].

В практическом смысле для «сухой» техники это означает, что подготовка ориентируется на аккуратное очищение, минимально травмирующую обработку прилегающих тканей и организацию рабочего места так, чтобы пыль и пары не накапливались в зоне дыхания мастера и клиента: для ногтевого сервиса как сферы труда описаны риски контакта с химическими веществами и аэрозолями, а также важность инженерных мер, прежде всего вентиляции.

Ключевой этап безопасной подготовки перед гелевым покрытием в сухой технике – контролируемое матирование (снятие блеска) и сглаживание неровностей без избыточного истончения пластины: для этого подбирают абразивность, которая считается подходящей для натуральных ногтей, и работают лёгким давлением, чтобы не «перепилить» поверхность. Профессиональные справочные материалы по пилкам сходятся в том, что диапазон около 180-240 грит относится к более щадящим вариантам для натуральных ногтей (формирование свободного края, деликатное сглаживание, подготовка под покрытие), тогда как более грубые абразивы предназначены для снятия искусственного материала и могут быть травматичны для натуральной пластины при неправильном применении.

В таблице 2 приведены примеры рекомендованных диапазонов абразивности пилок при подготовке натуральной ногтевой пластины под покрытие.

Таблица 2

Примеры рекомендованных диапазонов абразивности пилок при подготовке натуральной ногтевой пластины под покрытие

Диапазон (грит)	**Типичное назначение в открытых профессиональных описаниях**	**Примечание по безопасности для натуральных ногтей**
80-100	Очень грубая обработка, снятие «тяжёлого» искусственного материала	Для натуральной пластины обычно не рекомендуют из-за риска истончения
100-150	Грубая / среднегрубая обработка, укорачивание/формирование (чаще для искусственных покрытий)	Допустимо с осторожностью, но не как основной выбор для подготовки под гель на натуральном ногте
180-240	Средняя / мелкая абразивность для натуральных ногтей: формирование, деликатное сглаживание, подготовка перед покрытием	Обычно рассматривается как «щадящий» диапазон для натуральной пластины при лёгком давлении
240+	Мелкая абразивность для финишного сглаживания / мягкой доводки	Применяют для минимального воздействия на поверхность

Источник: [3].

Отдельный блок безопасности связан с химическими агентами (обезжиривание/очистка поверхности, испарения, пыль) и организацией рабочего места. В материалах по инфекционному контролю подчёркивается, что спирты (например, 70% изопропиловый) используются для дезинфекции внешних поверхностей оборудования в ряде случаев, но выбор средства и режима обработки всегда зависит от объекта и требуемого уровня обеззараживания.

Нанесение гелевых покрытий без нарушения целостности ногтевой пластины опирается на два научно подтверждённых принципа: покрытие должно быть полимеризовано в условиях, соответствующих спектру и мощности лампы, а контакт неполимеризованного материала с кожей и околоногтевыми тканями должен быть исключён, поскольку именно неполная полимеризация и попадание мономеров/олигомеров на кожу рассматриваются как значимые факторы риска нежелательных реакций. В современных публикациях подчёркивается, что материалы для ногтевого сервиса отверждают под действием УФ/LED-излучения, а спектр

излучения у разных ламп и устройств может различаться, поэтому корректное соблюдение технологических параметров (время экспозиции и совместимость «материал-лампа») является базовым условием правильного отверждения.

Важным риском при нанесении являются контактные аллергические реакции на (мет)акрилаты, применяемые в ногтевой косметике: в обзорной статье приведён анализ 38 775 пациентов, из которых у 769 (≈2%) выявлялись аллергические или раздражающие реакции на общий ингредиент, встречающийся в ногтевых продуктах. Поэтому в рамках безопасной техники принципиально важно наносить материал аккуратно, без затёков на кожу, и обеспечивать полноценное отверждение каждого слоя.

Дополнительно учитывается воздействие UVA-излучения на кожу кистей во время полимеризации. Американская академия дерматологии рекомендует перед гелевым маникюром наносить на руки водостойкий широкоспектральный солнцезащитный крем SPF 30+ либо использовать плотные тёмные перчатки с открытыми кончиками пальцев, чтобы снизить облучение кожи.

Безопасное снятие гелевых покрытий должно сохранять поверхностные слои ногтевой пластины, поэтому в дерматологических рекомендациях подчёркивается: не следует сдирать, соскабливать или агрессивно спиливать покрытие, так как это повышает риск истончения и повреждений ногтя.

Химическое воздействие растворителей важно учитывать так же, как и механику снятия: экспериментальные данные связывают частое воздействие ацетон содержащих средств с ухудшением состояния свободного края и изменениями межслоевых компонентов ногтевой пластины, что обосновывает принцип «минимально необходимого времени контакта» и отказ от травмирующих методов удаления.

После рассмотрения безопасного удаления гелевого покрытия становится очевидно, что сохранение ногтевой пластины зависит не от одного этапа, а от устойчивости всего цикла процедуры и условий её выполнения. Даже при аккуратном снятии риск истончения и микроповреждений возрастает, если не закреплены единые правила подготовки, нанесения, контроля материалов, гигиены и организации рабочего места. Поэтому далее целесообразно перейти к профилактическому подходу – стандартизации процесса и управлению качеством услуги через регламент, чек-листы и объективные критерии результата, которые позволяют получать стабильный безопасный эффект при повторяющихся процедурах (таблица 3).

Таблица 3

Профилактический протокол сохранения целостности ногтевой пластины

Этап (переход)	**Цель**	**Что обязательно по стандарту**	**Контроль качества**
До услуги → Подготовка	Выявить риски и не травмировать барьерные зоны	Осмотр ногтя и околоногтевых тканей; бережная работа с кутикулой; решение: можно / нельзя покрытие	Запись/фото «до», отметка рисков
Рабочее место → Процедура	Снизить пыль / пары и обеспечить гигиену	Включённая вентиляция / вытяжка; чистая зона; одноразовые расходники	Чек-лист: «вытяжка включена / зона очищена»
Инструменты → Подготовка ногтя	Исключить инфицирование и микротравмы	Очистка и обработка инструментов; исправность насадок / пилок	Журнал обработки + визуальный контроль перед работой
Подготовка ногтя → Нанесение	Не истончать пластину	Деликатное матирование, без «перепила»; минимальное давление	Контроль поверхности: ровно, без борозд/жжения
Нанесение → Полимеризация	Полное отверждение без контакта с кожей	Без затёков на кожу; время полимеризации по инструкции; защита кожи рук (SPF / перчатки)	Чек-лист: «затёков нет», «время выдержано»
Снятие → Завершение	Сохранить слои ногтя	Не сдирать / не соскабливать; щадящий метод снятия; защита кожи от растворителя	Фиксация метода снятия и состояния ногтя «после»
После услуги → Следующий визит	Предотвратить накопительный эффект	Рекомендации по уходу и интервалам; при признаках истончения — пауза/коррекция протокола	Запись рекомендаций, контроль жалоб/повторов повреждений

Источник: разработка автора.

Полученные сведения показывают, что целостность ногтевой пластины при сухом маникюре и педикюре с гелевыми покрытиями определяется не отдельным приёмом, а последовательностью действий на этапах подготовки, полимеризации и снятия, а также условиями рабочего места. Следовательно, профилактика повреждений должна быть организована как единый стандартизированный протокол с обязательными контрольными точками.

1) Перед началом процедуры оцените состояние ногтевой пластины и околоногтевых тканей и откажитесь от покрытия при выраженной ломкости, болезненности, повреждениях или воспалении. Рабочее место организуйте так, чтобы постоянно

работала вентиляция/вытяжка и не накапливались пыль и пары.

2) При подготовке ногтя выполняйте только деликатное матирование без истончения: минимальное давление, ограниченное число проходов, предпочтение более щадящим абразивам. Кутикула и боковые валики обрабатываются максимально бережно, без травмирования, чтобы не нарушать барьер кожи.

3) При нанесении геля не допускайте затёков на кожу и соблюдайте время полимеризации строго по инструкции производителя (материал должен полностью отвердеть). Для снижения воздействия UVA на кожу рук используйте SPF 30+ широкого спектра или плотные тёмные перчатки с открытыми кончиками пальцев.

4) При снятии покрытия запрещены сдирание, поддевание и соскабливание; выбирайте щадящий метод, контролируя глубину и исключая «снятие в ноготь». Если применяется ацетон, защищайте кожу вокруг ногтя, минимизируйте контакт по времени и обеспечивайте хорошую вентиляцию.

5) После процедуры обязательно фиксируйте состояние ногтя «после» (хотя бы краткой записью) и давайте рекомендации по уходу и интервалам; при признаках истончения или слоистости корректируйте протокол и делайте перерыв от покрытий.

Выводы

Таким образом, сохранение целостности ногтевой пластины при сухом маникюре и педикюре с гелевыми покрытиями определяется устойчивостью всего технологического цикла, а не отдельным приёмом. Наибольшие риски связаны с избыточной механической обработкой при подготовке, нарушениями режима полимеризации и травмирующим снятием, а также с недостаточным учётом условий рабочего места. Эффективной мерой профилактики является стандартизация процедуры: предварительная оценка состояния ногтя, щадящее матирование с корректным выбором абразивности, нанесение без контакта материала с кожей при соблюдении режима полимеризации и защите кожи, щадящее снятие без механического травмирования, обязательная фиксация результата и корректировка протокола при первых признаках истончения или слоистости.

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PEDAGOGICAL SCIENCES

ABOUT THE TEACHING OF ENERGY MACHINES AND TRANSPORTATION MACHINES APPLIED IN VARIOUS FIELDS OF NATIONAL ECONOMY IN TECHNOLOGY CLASSES

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Abstract
In modern times, the technology subject program (curriculum) serves the develop ment of the technological thinking of students of general education schools, the for mation of technological skills in them, and the acquisition of necessary knowledge to continue their education in the next stages. In the article, the structure and opera tion status of energy machines taught in high school is explained, the types of machi nes, their importance and how to facilitate human labor are noted. It is also explained in those lessons that transport and power machines play a key role in many heavy and light industries. Thus, the students are given extensive information about the transportation of all the products that are beyond the reach of humans by using these transportation machines in various fields of the National Economy. At a time when radical changes in technologies are taking place at a great speed, teaching the application areas and importance of these technical equipment to students leads to their even more information in this field and the expansion of their technical knowledge. In the research work, the wide application of energy and transportation machines in various fields of the national economy, their areas of use, types, etc. has taken a wide place. The center of attention in the research work is the process of forming the methodical system of mastering the information about energy and transportation machines, their working principles, the contemporary "techno-democratic-informational society" references, the realization of the expected results as a component of the information that should be mastered to the students. The professions and specialties that students will choose in the future, in turn, require the acquisition of new knowledge, habits and skills. In one way or another, the close connection of all fields of the national economy with the science of technology has been shown.

Keywords: Generator, forklift trucks, stator, manual transmission, steam transmis sion, Lawrence force, electric power, elevators, escalators, electric and internal combustion engine transmission, lifting mechanisms, cranes, hoists.

Relevance of the research topic: The preparation of the growing generation for life and practical activities includes the preparation of qualified professionals according to the demand of the pace of development in our country. This reality is reflected in the "Education Reform Program of the Republic of Azerbaijan".

In the social, economic, and cultural life of our country, a complex program of reforms is implemented in accordance with the challenges of the modern era.

One of the goals of choosing education as a priority direction in this process is to prepare the emerging generation for life from an early age.

Information about technological machines, devices, tools and mechanisms contained in the content of the expected results in the teaching of the subject "Technology" in general education schools, their working principles have an "enabling function" and the formation of a methodical system aimed at its mastery is a "didactic cognitive issue". This issue is related to the broader problem of system formation. The functioning of the system aimed at realizing the expected results in the subject "Technology" makes that problem permanent. Therefore, this topic can be considered relevant

Interpretation of generalizations formed on the basis of research materials. In the economic and cultural life of our country, a complex program of reforms adequ ate to the challenges of the modern era is being implemented. It is known that the formation of the educational space is based on the "man-society-technology (which is becoming adequate to the challenges of the IV industrial revolution)-nature" paradigm, which is a condition for the human struggle for freedom or the development path towards civilization.

Technology is constantly updating itself and developing. It is a variable event, the invariant is not specific. Therefore, it is possible to encounter a new technological development every day. This development affects a person's life. Innovations and technological development have a positive impact on people's lives. It is already known to all of us that the 20th century was characterized by the rapid development of science and technology, the development of new technologies, scientific and practical innovations, information and communication technologies, and entered history as the information age, the age of science and education in a broader sense. [4;53]

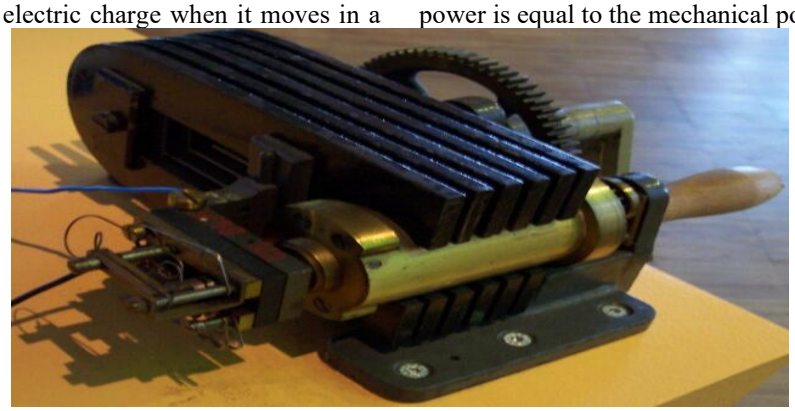
The 20th century is characterized by the rapid development of electrical engineering. Thus, the quantity, size and power of the produced electric machines are continuously increasing, their structural structures are improving and their mass per unit power is decreasing.

Electric machines are one of the most basic elements of electrical equipment widely used in industry, agriculture, transport, military equipment and household in modern conditions. Man uses different machines in his work. The main purpose of their use is to lighten human labor. Power machines include electric power generators. [5;23]

Generators convert mechanical energy into electrical energy. They are used in power plants, various transport devices, cars, airplanes, ships, locomotives, mobile power plants, etc. is installed. In power plants,

they are rotated by powerful steam or hydraulic turbines, and in transport devices by internal combustion engines or gas turbines.

Generators are also used in communication and automatic devices, measuring equipment, etc. they use as a nutrient source. The working principle of all generators is the same. Mechanical energy is used to rotate the shaft of the generator. The transformation is based on the Lorentz force. The Lorentz force describes the force acting on an electric charge when it moves in a magnetic field. If a conductor moves transversely in a magnetic field, the Lorentz force moves the charges on the conductor along the conductor. The movement of the charge creates a voltage difference across the ends of the conductor. To increase the voltage, they use conductors in the form of loops. In the generator, the rotor rotates relative to the body. When a stator with a magnet on it rotates in a magnetic field, the Lorentz force creates an electric current. The obtained electrical power is equal to the mechanical power.



Modern electrical engineering has achieved great success. New series of electric machines have been developed and the issues of mastering them with high precision are being investigated, new magnetic, winding and insulation materials are being applied to improve the energy and other indicators of the machine. [6;8]

Motor vehicles need electricity to power their devices, keep the engine running and charge their batteries. Until about the 1960s, motor vehicles tended to use DC generators (dynamos) with electromechanical regulators. Following the historical trend above and for many of the same reasons, these have now been replaced by alternators with internal rectifier circuits.

At present, various types of forklift trucks are used for lifting and lowering loads in enterprises operating in almost all fields of industry. Lifting-carrying machines allow to increase the productivity of the industrial enterprise by automating this type of work, as well as eliminating heavy work related to loading and unloading.

Lifting-carrying machines (LCM) technology has developed very widely and forms the main part of the machine-building industry. These machines are integral and basic mechanical equipment of modern industrial enterprises. Quite rightly they are called "hands of production".

An important task of the QNM course is to learn the means of mechanization in the transport of goods in various fields of industry and agriculture.

The correct selection of lifting equipment is one of the main conditions for the normal and high productivity of production.

The use of lifting transport devices in human life belongs to the ancient historical period. Archeological excavations and constructions of historical monuments that have survived until now show the attempts of people to facilitate the lifting and transportation of loads and to lighten labor-intensive tasks with the help of primitive mechanisms. In the 16th and 17th centuries, a small amount of metal was used in lifting devices. However, starting from the 18th century, metal began to be used in these devices. The development of industry and technology, which began at the beginning of the 19th century, laid the foundation for the development of the lifting transport and machine building industry. In 1827, the first stationary steam crane was developed, and in 1880, a steam locomotive working together with a crane was developed for the first time in Russia. The vertical steam boiler placed in this steam locomotive also performed the duty of the opposite load. This faucet was a fully rotating faucet. Starting from this period, lifting machines began to develop rapidly. In 1877, the

first floating steam crane was built, and in 1880, the cable crane was built. In connection with the discovery of electric transmission at the end of the 19th century, an electric rotary crane in 1885, an electric bridge crane in 1887, and a perfect three-mechanism electric bridge crane were built and put into use in 1889. Starting from the beginning of the 20th century, forklifts and electric drives almost replaced the steam engine.

Internal combustion engines were used in forklifts only in 1895.

There are 3 main periods in the history of the development of lifting machines.

1 - Manual transmission machine.

2 – Steam engine.

3 – Electric and internal combustion engine transport vehicles.

In the development of the material technical base, in the improvement of economic indicators, the role of lifting and transporting machines is great.

Modern technological and automatic flow lines, loading and unloading of inter-shop and intra-shop transport require the application of various types of lifting and transporting machines and mechanisms to ensure the rhythmic and uninterrupted operation of production processes. That is why lifting and transporting equipment has not been an auxiliary tool in production processes, but has become a factor that determines the capabilities of modern productions.

The correct selection of lifting and transporting equipment is a decisive factor for ensuring the normal operation and high productivity of factories. Modern high-performance forklift trucks with high speed and large lifting capacity have been gradually developed over a long period of time. The primary means of mechani zation were: supports, rollers and inclined planes. Carrying out large-scale construc tion works using such mechanization means requires the use of a large number of people. For example, more than 100,000 people have always been engaged in the construction of the Xeonsa pyramid, which has been under construction for more than 20 years. Boom lifts - a type of modern arm cranes - were used to raise water as early as the 22nd century BC.

Forklifts are the main equipment in the field of mechanization of transport work in factories, factories and other industrial enterprises. Lifting and transporting loads is hard physical work. To mechanize this work, lifting transport machines are widely used.

Forklift trucks are given the exact name "Lifting transport vehicles" in the full sense. These machines are not only used to lift loads, but also transport them to certain destinations. So, forklifts are mainly used to lift and transport loads. These are included in the group of vehicles used periodically.

Forklifts are divided into three main groups.

1. Lifting mechanisms
2. Faucets
3. Lifters

The group of lifting mechanisms includes winches, jacks, hoists, manual and electric hoists and birail trolleys.

The group of cranes includes jib cranes, bridge cranes, rail cranes, crawler cranes, tower cranes, cable cranes, floating cranes, etc. includes

The group of elevators includes elevators, elevators and other such mechanisms that lift goods and passengers in vertical and inclined directions.

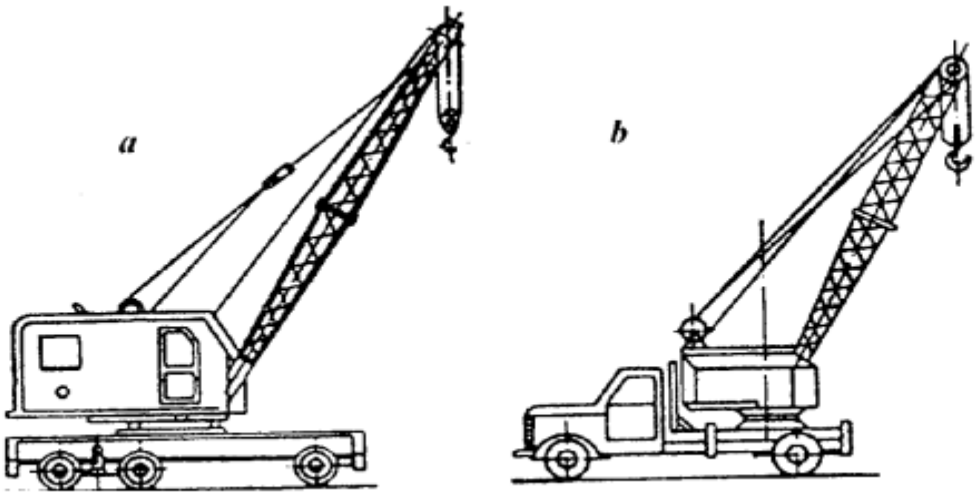
Machines that lift the load and move it in certain directions are called cranes. Cranes are made in different structures depending on the working conditions. However, despite the variety of construction of cranes, their mechanisms mainly consist of lif ting, moving and turning mechanisms. Thus, some are equipped with lifting and two-way movement mechanisms, others with lifting and turning mechanisms, lifting movement and turning mechanisms. Manual cranes are called "hand cranes", and electric cranes are called "electric cranes". In addition to these, there are also cranes that work with a steam engine and an internal combustion engine (railway cranes, tractor and car cranes, etc.).

Cranes are used to mechanize loading and unloading operations in industrial enter prises, construction sites, river and sea ports, railway transport, etc. Lifting cranes load-carrying arrangements provide lifting, short-distance transportation and lowering of loads by means of a vehicle.[2;8]

Hoisting cranes are divided into different types according to the constructions, displacement, type of transmission of mechanisms, degree of rotation and method of fixing.

According to their construction, cranes can be bridge, leveling crane type, arm and self-propelled. Overhead cranes include bridge, jib, bridge loader-unloader, cable and bridge cranes. Boom cranes include tower, portal and console cranes, and self-propelled cranes include crawler, rail and floating walking cranes.

According to the design of the crane, hook cranes (for lifting various loads), mag netic cranes (for transporting steel and cast iron loads), clamp cranes (for lifting barrels, boxes, bags, etc. loads), traverse cranes (loaders based on traction force air pressure) provided with equipment), can be an automatic loader (for transporting containers).



Şəkil 1.1 Kranlar :a- pnevmotəkərli; b-avtomobildə yerləşmiş

Depending on the type of displacement, lifting cranes are stationary and movable. According to the type of rake device, it can be rail, pneumatic wheel, crawler, rope, walking and floating type.

According to the type of mechanism transmission, cranes are manual, electric, hydraulic, pneumatic, internal combustion engine, steam or combined transmission.

According to the degree of rotation of the arm, the cranes are divided into full-turning, full-turning and non-turning cranes.

Depending on the method of leaning on the crane road, there are support and suspension type cranes. [1;3]

There are also column lifting devices. They help lift construction materials to higher floors in construction sites.

In our modern world, the demand for elevator equipment is increasing day by day. The construction of new high-rise buildings, "skyscrapers" increases this demand and makes elevators indispensable. The first elevator device was created in the 16th century, similar devices were used in ancient Egypt. Elevator devices are updated from time to time and reflect the latest achievements of science and technology today. [11;9]

An elevator is a lifting device. For several centuries, it has been used to transport people and goods from one level to another in a vertical direction. During this period, the elevators have undergone a rich development, improved, reliability and safety have been increased, the control system has been simplified, and the interior (artistic design of the interior) has been beautified. Modern elevators have a perfect design and interior, a high-level electronic control system. Now it is impossible to imagine modern skyscrapers, magnificent business centers, high-rise residential buildings without elevators. Elevators are usually installed inside the building, in a special basement. In loading (unloading) areas, the warehouse is equipped with automa tically opening doors. An elevator is a cyclically moving lift-carrier that lifts and lowers people or goods from one level to another in a cabin moving along vertical guides. Elevators are usually installed inside the building, in a special shaft. In the loading (unloading) areas, the shaft is equipped with automatically opening doors. [12;42]

Fibers can be divided into the following types:

According to the type of transported cargo: Passenger elevators - for transporting people whose total mass is not greater than the lifting capacity of the elevator and small cargo belonging to them. Currently, the number of elevator modifications and different types of lifting devices is quite large.

Classification by destination: For passengers, for cargo, for cargo and passengers, for hospitals, for cargo platforms, for industry.

Depending on the purpose, there are the following types: Passenger elevators for residential buildings; Passenger elevators for administrative buildings; Passenger elevators for public buildings; Elevators for low-rise buildings (cottages) - elevators with a speed of up to 0.63 m/s can be installed in buildings with up to 5 floors. Hospital elevators are used for the transportation of patients and their accompanying staff in internal transport vehicles in treatment and prevention institutions. Such elevators are operated by an elevator operator. Handicapped elevators are passenger elevators that are operated by passengers who have lost the ability to move and walk in wheelchairs themselves. Freight elevators. It is divided into the following groups: Conventional cargo elevators - cargo lifting capacity is 250-5000 kg; Guided freight elevators - for transportation of goods and accompanying passengers; Unmanned freight elevators - for transporting goods only. [11;18]

Elevators are divided into 4 main types according to the lifting mechanism as follows:

Hydraulic Lifts

Hydraulic elevators are supported by a piston at the bottom of the elevator that pushes the elevator up. They are used for 2- to 8-story low-rise applications and travel at a maximum speed of 200 feet per minute.

Traction Elevators

Traction elevators are raised by ropes that pass over a wheel connected to an electric motor on top of the elevator shaft. They are used for medium and high-rise applica tions and have higher travel speeds than hydraulic elevators.

Climbing Elevator

They keep their power devices mostly on electric or combustion engine. Climbing lifts are often used in work and construction sites.

Pneumatic Lifts

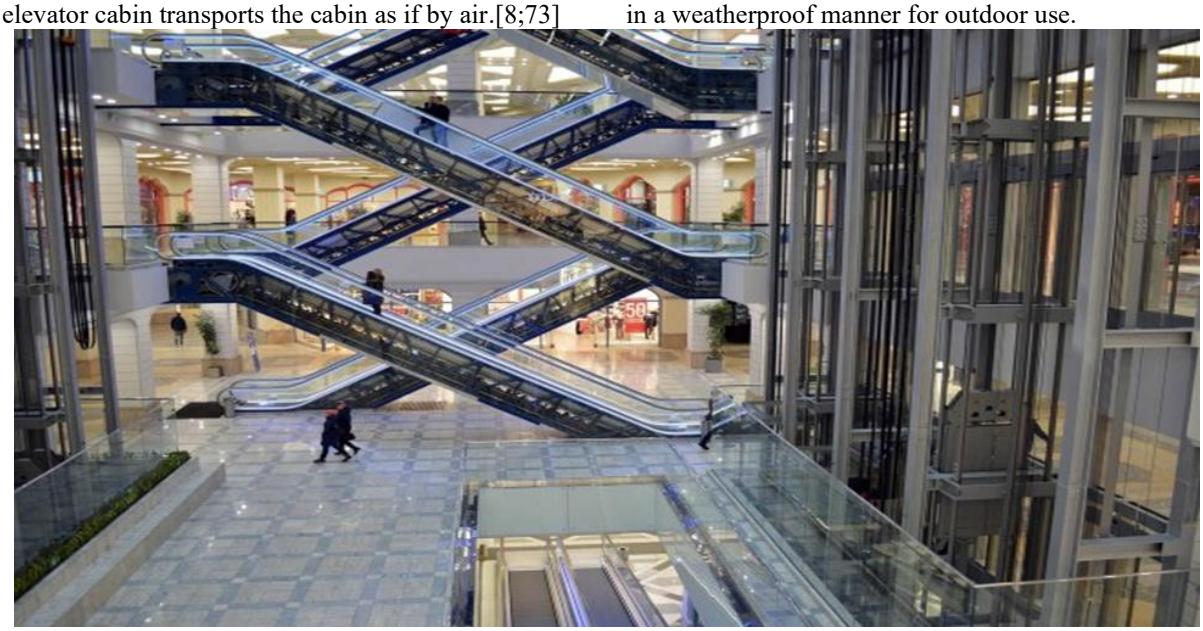
Pneumatic elevators are raised and lowered by controlling the air pressure in the chamber where the elevator sits. With simple principles of physics; The difference in air pressure above and below the vacuum elevator cabin transports the cabin as if by air.[8;73]

Transporters also include escalators that carry people.

Escalator

It is a moving staircase – a conveyor transport device for transporting people comfortably and safely in large buildings, hospitals, public buildings, pedestrian crossings, etc. The best advantage of escalators is that the user who is going from one place to another can reach it faster. It is also quite convenient and convenient for the older generations.

Escalators, which have the capacity to carry more people than elevators, are usually used in places where elevators are impractical or in conjunction with them. The escalators, which can be easily installed at the same clearance distance as the stairs, are also manufactured in a weatherproof manner for outdoor use.

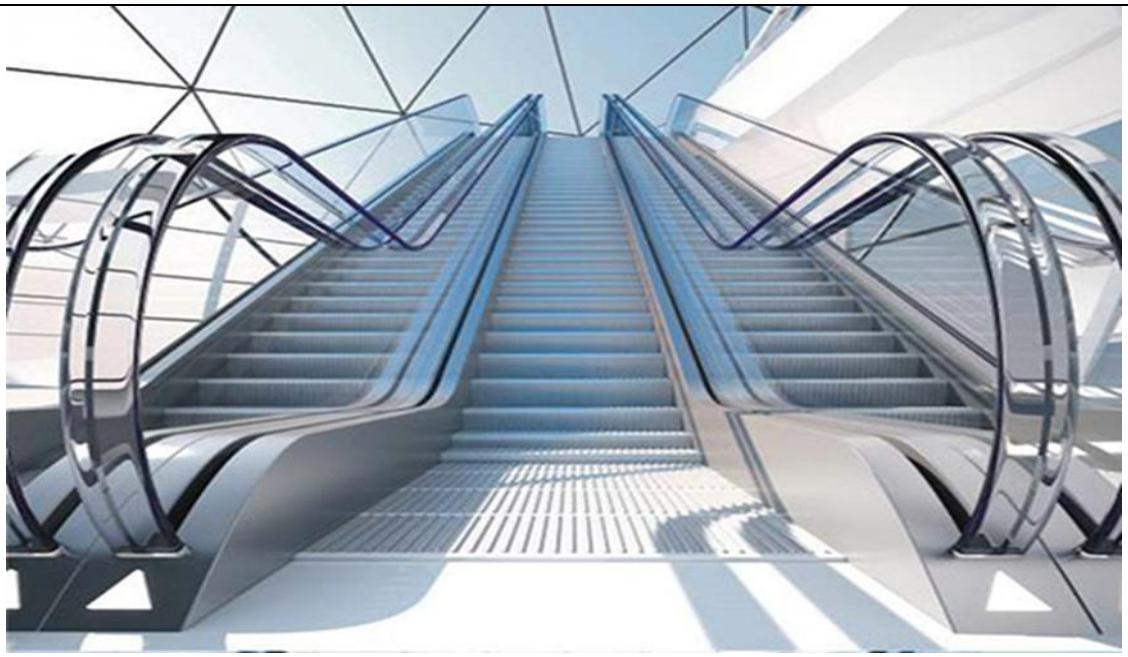


The direction of movement (up or down) can always be the same or automatically changed by the staff depending on the time of day. (the system is programmed so that the direction is not changed while the passenger is on the escalator). [10;26]

There are 4 typical forms of escalators:

"side by side or separated by distance" (up and down escalators) often seen in Parallel-Metro stations and multi-level cinemas.

Cross- Commonly used in department stores or shopping malls. By "stacking" escalators going in one direction, the structure minimizes space requirements.



Lots of parallels–Two or more escalators moving in one direction next to one or two escalators moving in the other direction on one bank.

Next to the stairs "Up" or "Down".

According to the Regulations on Health and Safety in the Use of Work Equipment, escalators and stairs must be inspected at least once a year. In addition, it must effectively and safely lift at least 1.25 floors of the declared load, unless otherwise specified in the relevant standards. There should also be a brake system to stop the load and to hold the load in case of danger. [10;71]

The scientific outlook of the future engineer, technician, technologist begins to emerge in high school, and is formed and strengthened in higher school. The importance of the scientific worldview increases even more during the independent labor process where the young specialist starts working in the industry and makes optimal decisions.

In modern conditions, where scientific and technical progress is organically connected with the advantages of the economy, the importance of secondary education in training specialists with comprehensive knowledge in higher schools is great. [13;54]

Scientific significance of the study: Science acts as the basis of productive forces and has acquired the status of the means of labor, the subject of labor and the joint element of labor power. If knowledge is expressed as a tool for both expanding the scale (quantitatively) and increasing the efficiency (qualitatively) of material production, then designing advanced technological processes, machines and equipment, and theoretically justifying the perfect organization of production to achieve them is the direct goal of science. It is important that today's student, who will be the expert of the future, be educated in the spirit of loving scientific and social activities, and that his worldview is formed correctly. Scientific outlook is based on scientific knowledge and reasoning.

In the technology classes, the teaching of the application fields of heavy and light industries of the energy machines and transportation machines, the rules of use of the national economy helps to form the scientific worldview of the students, and lays the foundation for growing up as a citizen of the modern "techno-democratic-informational society".

Practical significance of research. In order to regulate the successful and developing environment of students, it is possible to raise the efficiency level of the practical pedagogical activity based on the interpretation of the theoretical and technological directions of the arguments that are considered important and the possibilities of the educational process at different levels of general education. Scientific and technical progress reflects the strengthening development of the interaction between science and technology. This manifests itself in the organization of productive forces, technology, management methods and production. Scientific and technical progress has two forms of development. Productive forces are always developing, techniques, technology and other areas of production are constantly being improved. Qualitative changes are taking place in science and technology, which in turn lead to profound new structures in all production. There comes a time when previous techniques and technology are out of order. At this time, due to the emergence of a completely new type of energy, materials, techniques and technology, and on the basis of gradual changes, quality leaps occur in the development of production. This is a revolutionary form of scientific and technical progress. Scientific and technical revolution is a component and the highest stage of scientific and technical progress.

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PECULARITIES OF THE METHOD OF DISCUSSION IN THE FORMATION OF FOREIGN COMMUNICATIVE COMPETENCE OF STUDENTS IN TEACHING A FOREIGN LANGUAGE

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Abstract

The article deals with the problem of discussion in activating communicative competence of students in language teaching. The authors expose that teaching a foreign language as a tool for communication continues to be a primary concern in modern methodology. Recently, the focus on the type of learning that stimulates the development of the student's personality and activates their potential has become more widespread. The article substantiates the idea that foreign-language communication is the ability to listen and properly understand the interlocutor, logically and reasonably express an opinion, prove a certain conclusion, find the right solution to a problem, or a way out of a conflict situation. Particular attention is paid to the linguodidactic value of discussion in the formation of foreign language communicative competence. Linguodidactic value of discussion identifies the characteristics of discussion as a communicative method and the conditions for its effective implementation, and presents the basic skills required to participate in a discussion. The authors describe the structural elements of the principles and approaches of discussion in the formation of foreign-language communicative competence. It points out that the discussion used as a method contributes to the activation of students' speech interaction, increases intrinsic motivation to learn a foreign language. It is believed that using discussion as a method contributes to the activation of students' speech interaction and increases intrinsic motivation to learn a foreign language. The authors suggest that the discussion methods hold an intrinsic worth. However, the concept of “discussion method” is clarified in the article and the practical application is shown in the educational process. Finally, the authors give recommendations for the successful organization of discussion. So, the aim is to determine the effectiveness of using discussion in the process of forming students' foreign-language communicative competence. The result of this article showed that discussion method could increase communicative competence of the learners.

Keywords: foreign communicative competence, discussion, formation, foreign language, student, approach, principle.

Introduction

In modern times, higher education institutions strive to not only equip their students with the necessary knowledge and skills for their chosen field, but also to cultivate a lifelong learning mindset in them. This includes the ability to engage in self-development and self-education, adapt to changing circumstances, think critically and creatively, and communicate effectively, particularly in foreign languages (State Compulsory Standard, 2012). To achieve this objective, it is crucial to prioritize language training for students. The national compulsory standard for higher education in the Republic of Kazakhstan highlights the formation of foreign communicative competence as one of the key outcomes of training. This involves equipping students with the skills to communicate effectively with professionals and non-experts, as well as the ability to communicate appropriately in various cultural, social, and specific contexts.

The issue of teaching discussion in a foreign language occupies one of the leading places in the modern foreign language teaching methodology. A significant contribution to the development of the problem of teaching discourse in a foreign language was made by methodologists who studied various issues, in particular the development of discussion skills as a component of interactive foreign language competence (Chekoldina, 2005), methodological foundations of teaching discussion communication in a foreign language (Azarchenko, 2020), discussion as a method of forming foreign language speaking skills (Salieva, 2016) and foreign language communicative skills (Kopzhasarova, Toktau, 2018).

The research questions were:

- to determine the meaning and significance of educational discourse;
- to define the principles and approaches of discourse;
- to develop tasks for assessing the effectiveness of educational discourse.

However, the substantiation of the peculiarities of organizing the teaching of foreign language discussion with the use of problematic situations has not received proper research.

Different researchers give contrasting approaches in using discussion in teaching foreign languages. Discussion is often regarded as a methodological technique

for developing unprepared speech. It supposes, participation in a discussion will be enough for students to transmit a knowledge about the procedure of discussion (G.A. Rubinstein, V.L. Skalkin, 2012). This approach supposes that discussion skills can develop directly in the process of training.

On the contrary other scientists (Koblova, 1973, Korosteleva, 2020) consider purposeful formation of discussion skills to be a determining factor in teaching foreign language. The operational base is undoubtedly formed by the skills of logical thinking, argumentation, and counter-argumentation, which have to be developed in the teaching process.

Foreign language communicative competence determines the ability and readiness of the student to carry out activities on implementation of communication in a foreign language. Foreign language communicative competence implies the development of abilities and skills in the main types of speech activities, such as speaking, reading, listening, writing, and knowledge of phonetics, grammar, vocabulary, as well as the skill of mastering these above-mentioned competences. E.V. Bibikova shows foreign language communicative competence "as a system formation in a set of motivational, functional and reflexive components (Bibikova, 2006).

In the conditions of the transition to the state standard, the formation of foreign communicative competence of students in the specialty 'Foreign language: two foreign languages' is impossible without knowledge of the English language. Therefore, the relevant method in the formation of foreign communicative competence becomes a discussion. According to A.P. Panfilova, a discussion is "an exchange of opinions on a certain issue in accordance with more or less definite rules, procedure and with the participation of all or individual participants" (Panfilova, 2005). The confrontation of different points of view and positions stimulates speech activity. This forms the ability to calmly listen to the arguments of the opponent, teaches cooperation and critical thinking.

In modern science, there is no unity in explaining the meaning of the term" discourse". However, in many works of domestic and foreign scientists there is a tradition that the word "discourse" is interpreted as a product of speech in a different composition of its cognitive and communicative function.

According to O. F. Rusakova: “discourse” is a speech that, as some researchers note, is figuratively “brought to life” (Rusakova, 2014). Therefore, the term “discourse”, unlike the term “text”, does not apply to ancient and other texts whose connection with living life is not directly restored.

The concept of “discussion” has been analyzed by foreign researchers from different points of view. One of the foreign scientists Yu.S. Stepanov gives the concept of discussion as “language within a language” (Stepanov, 1995), and at the same time V. Z. Demyankov gives the idea that discussion is a mental text consisting of sentences and fragments (Demyankov, 2015).

T. A. Van Dijk defines discussion as a verbal form of objectification of the content of consciousness, regulated by the prevailing type of rationality in a particular socio-cultural tradition (Van Dijk, 2008].

As for M. McCarthy and R. Carter discourse is a communicative form which is addressed to interlocutor, listener or reader and it has the following characteristics: cohesion, coherence, pattern (McCarthy, Carter,1994).

According to B. N. Karasik, "communicative discourse applies not only to linguistics; it has an interdisciplinary character. Therefore, it should be understood as a category aimed at regulating the objective perception of society and the peculiarities of interaction within it" [Karasik, 2007].

A. K. Adilova points out the common features and differences of discourse:

- Discourse is broader than text and includes a concept. It is a speech process.

- Discourse is a set of language tools that are requested depending on the authors’ intention and style characteristics.

- If discourse is a way of transmitting information, then the text is a multifaceted, multi-layered structure that stores information, accumulates it, and creates new value (Adilova, 2009].

Discourse is a speech activity that takes place between communicants at a certain time and place. That is, the verbal execution of situations in their lives is transferred to the text and preserved in the language as a result of discourse.

The main features of discourse have been analyzed by G. N. Smagulova based on the following characteristics:

1) Based on the content around the discourse of a particular topic, in some cases, there may be a change in the subject.

2) Social orientation and uncertainty of the volume of the text.

3) The content completeness of the discourse is determined by the communicative situation, and if thematic communication is performed, then non-verbal signals are expressed, such as the completion of the text, pauses, and transition to other topics. Therefore, it is impossible to analyze discourse outside of communication relations [Smagulova, 2008].

Communicative discourse expresses the concretization of speech and stable forms of use of speech, communicative behavior, and communication. Communicative discourse characterizes the formal interpretation of communication, the functional interpretation in the formula of the use of language and its units as a communicative and situational nature, and as a characteristic of socio-psychological and socio-cultural situations.

Therefore, discussion method is not only a product of speech activity, but also the process of its construction. The discourse is determined by extralinguistic factors, such as the communicative context and the conditions of communication. At the same time, the strategy of verbal communication, the verbal and non-verbal behavior of communicants, as well as the type, form, and content of the created or perceived text, are determined by this cultural context and the communicative goals of communicative individuals.

Methods and materials

The purpose of this study was to study the level of formation communicative competence under the means

of discussion. In our study, the authors made an attempt to experimentally test the formation of communicative competence under the means of discussion. Experimental work was carried out to determine the effectiveness of using the discussion method in foreign language classes.

The discussion, unlike other methods, allows you to use the discussion as a mental tool that gives each participant the opportunity to understand their inner world and the world of others, to see themselves from the outside and through the eyes of other people, to see the possibilities and directions of their own change.

During the discussion, co-creation relations are created between the participants, which provides a more intensive process of self-development and self-realization, contributes to the rethinking of one's own experience. The discussion was realized through assignments at seminars in the discipline "Methodology of foreign language education".

The purpose of the article was to investigate the extent to which speech skills of students can be developed through the use of educational discussion. As a control group was taken 3rd year students of the specialty 6B01705 “Foreign language: two foreign languages” Zhetysu university named after Iliyas Zhansugurov (Taldykorgan, Kazakhstan).

The aim of the article is to determine the peculiarities of the organization of teaching foreign-language discussion in higher education.

Objectives of the research:

- based on the analysis of scientific literature to determine the peculiarities of foreign-language discussion;

- to substantiate the stages of teaching discussion using problem situations in the foreign language classes at the university.

The introductory part of the article describes the essence and content of the educational discussion.

Discussion method has a collaborative, social character, representing inter-subjective and playful activity and fulfilling learning, developing, educational, and stimulating function. In order to organize discussion communication, students must have a high degree of maturity and independence in acquiring knowledge and formulating problems, in selecting and clearly presenting their own arguments.

Discussions can be held in small groups and it is important to determine what teachers call small groups (4-6 students). Teamwork not only increases student engagement, but also promotes the development of social skills, better communication and more autonomy (Karaev, 1997).

The discussant must be able to express his/her opinion accurately, to build a logical argumentation, to refute an opponent or convince him/her of the correctness of his/her point of view. At the same time, the discussant should remember the need to find a joint solution, which encourages him/her to listen attentively to his/her interlocutors and to correlate their statements with his/her own arguments. All these skills and abilities, formed in the process of educational discussion, are the key to successful communication.

The organization of the discussion predetermines and reinforces the verbal confrontation. In turn, this helps to establish interaction between the participants and regulate the entire discussion process. Discussion is critical to the productive exploration of a problem. In order to fruitfully investigate an instructional discussion problem, it is necessary to know and master the principles that help students interact with each other and determine the entire discussion process that follows.

The process of forming students' foreign-language communicative competence under the means of educational discussion is organized in accordance with certain principles. They reflect the internal essential sides of students’ activity; determine the effectiveness of learning in various forms with its content. The principles also, express the normative foundations of learning.

When determining the principles of the discussion, the authors took as a basis the principles of the author T.E. Damer The researcher thinks that these principles will help the productive work of the discussion in teaching a foreign language. In the formation of foreign language communicative competences in the learning process the following principles: principle of the search for truth, principle of clarity and principle of acceptability (Damer,2009).

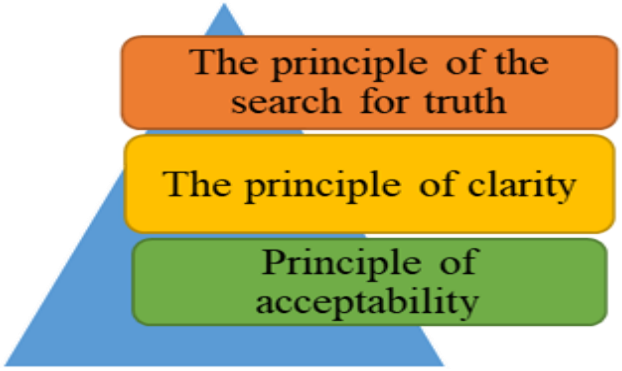

Figure 1. Principles of discussion in formation foreign communicative competence (Complied T.E. Damer).

The principle of seeking the truth - the concept of "truth" in a particular case is difficult to define; the best solution is the position that is most acceptable to all parties. Therefore, it is necessary to be prepared for alternatives that diverge from your own, to gather information about them in advance if possible, and to allow

other participants to present arguments or object to any position related to any controversial issue.

The principle of clarity – implies asserting and supporting thoughts with arguments, and our speech should be as simple and clear as possible. It is necessary to show clearly where our position is congruent with that of the opponent, and where it is inconsistent.

The principle of acceptability is to share universal values and knowledge, so that in most cases, it is possible to find a commonly known point of view on an issue that is clear to everyone, and to start from it in our further reasoning.

The success of setting goals for the formation of foreign communicative competence in discourse depends on how competent and linguodidactic approach is used. The competence approach is optimally combined with active and interactive methods of learning, which are most often characterized by a combination of non-standard forms, means, and methods aimed at organizing the educational space. A person's personality develops in the process and as a result of solving situations that are vital to them. To develop professional thinking and organizational skills, it is necessary to systematically put students in conditions that allow them to exercise one or another type of activity.

The aim of the communicative approach in teaching a foreign language is to develop foreign communication skills and abilities in the target language (Lebedev, 2004). Discussion stimulates the speech activity of students and enables one to adopt a differentiated approach towards the formation and development of communicative abilities and personal qualities. This, in turn, allows students to adapt in the social environment and effectively solve the problems of personal and professionally significant communication.

Effective education of students today requires methodologists to work in a new direction. That is why many scientists and methodologists-teachers, as a result of their research and experience, came to the conclusion that one of the ways to revive the learning process is to use training and tasks in the classroom with a sample of various new technologies [Westwood, 2008].

The task “Working in group”.

The aim of the task: to develop the ability to place and analyze the situation from the point of view of another person. Description of the task. The teachers are asked to divide into two equal groups: the first group is “trainees” and the second is “teachers”. Each group is offered to discuss the task and create rules in the group. 3-5 minutes are given to work in groups. After the discussion, each group should write its own rules with markers and choose the person who will represent the outcome of the group’s work.

Groups take turns to present the results of their work, and then together select the same rules, discuss them and create general rules based on positive language, without writing them out on a blank sheet, and each signs under these rules, the rules are placed on the board.

At the end of the work, an exhibition of drawings is made and samples are posted. Group members discuss the results.

How did you feel about being the "intern" and the "teacher"?

Would you like your work to be appreciated, why?

The next topic: “Learning environment is a source of spiritual wealth”. Taking part in the discussion on this topic, students were required to prove their point of view on this issue and be able to defend it. At the beginning of the lesson, students were divided into groups of supporters and opponents.

The purpose of the discussion method is as follows: firstly, the students have the ability to speak freely, correctly; secondly, it develops the system of thinking, expands the worldview; affects the formation of personal views as a person; thirdly, forms virtues, moral qualities. The task of the group of supporters participating in the discussion lesson: they introduce their group, defend their individual point of view on each argument, answer counter questions and ask questions. Opponent group also introduce themselves, object to the arguments of their opponents, and ask questions.

Both groups should proof:

1. What is the educational environment and what it is like?

2. Implementation of the modern educational environment and necessary initiatives / steps to overcome them.

3. The person who stops working in group also stops thinking.

4. The learning environment encourages students to find the necessary information on their own.

The final part of the discussion is the conclusion of it. The results of the thought section are summed up by the teacher.

Based on the above, the authors can emphasize that the principles and approaches of discussion application in the formation of foreign language communicative competence give students ample opportunities for the development of speech skills and the activation of foreign language communication. It helps to stimulate interest in the subject and serves the best assimilation of lexico-grammatical material.

The authors consider it appropriate to use discussion at all levels of foreign language teaching because it not only adds variety but also makes the lesson bright and dynamic.

The discussion method provides students with the chance to analyze received information and reach a well-reasoned decision together on the given topic. This method also aids in removing communication barriers, improving their vocabulary, and effectively planning their statements.

Furthermore, it facilitates active and thorough learning and encourages interaction between students. Through discussions, students can compare and assess their viewpoint, which in turn boosts their educational and developmental skills. Ultimately, discussion method stimulates students' speech activity.

Results and discussion

To evaluate the progress of discourse learning, it's essential to establish the standards and signs that enable us to track their progress over time. Considering the diverse interpretations of these terms, it's important to clarify their definitions. A criterion refers to a qualitative feature of a phenomenon or concept that is based on common characteristics, and it serves as the foundation for any classification. It represents a generalized

attribute of development within similar systems, allowing for differentiation between them [24, p. 98]. On the other hand, an indicator describes a quantitative or qualitative feature of the studied object that depicts the phenomenon concerning criterion evaluation [Zeer, 2007].

Based on the analysis, the authors have identified the criteria for the effectiveness of learning discussions in the process of participation in the discussion. The indicators and criteria for the effectiveness of learning discussions include the following: actively participating in the discussion and formulating one's own viewpoint, attentively considering and acknowledging the perspectives of others, presenting and advocating for one's own stance, and public speaking.

Summarizing the studied materials, the authors have distinguished three universal criteria for the effectiveness of educational discussion: dialogicality, creativity, and reflexivity. Communicativeness is an indicator of the criterion of dialogicality, referring to the capacity to initiate and sustain connections grounded in the principles of dialogical communication. Indicators of the creativity criteria are the number of ideas arising per unit of time, originality (the ability to produce unusual ideas that differ from the conventional), and flexibility. An indicator of the reflexivity criterion is the ability to analyze and self-analyze, evaluate and self-assess, plan and forecast activities and their results.

Based on the principles, approaches, and criteria the authors have developed, a number of tasks were given to the students. The following topics were developed with the students:

1) It is suggested that higher education in higher educational institutions should be fully paid for.

2)The introduction of the Bologna system in Kazakhstan disrupts the educational process.

When discussing the first topic, students made the following conclusion: The question of whether higher education should be for a fee is not just about money. It is a question of the value of four years of a young person's life for their future. The question of whether it is worth attending university and whether one should have to pay for it will continue to be debated as long as the value of obtaining a diploma is not apparent and its link to future success is not always established. The question remains open and requires further discussion. It is not necessary to go to university right out of high school, as 65% of freshmen have maintained contact based on the values of dialogic communication and what they want out of life.

However, I still think that higher education is necessary. The main thing is to find a reputable university and consume education properly, not just attend classes with an iPhone. 16% of respondents were able to produce unusual ideas that the importance of a university degree is greatly exaggerated. 19% believe that planning and forecasting activities are necessary, and it is essential to learn another profession independently.

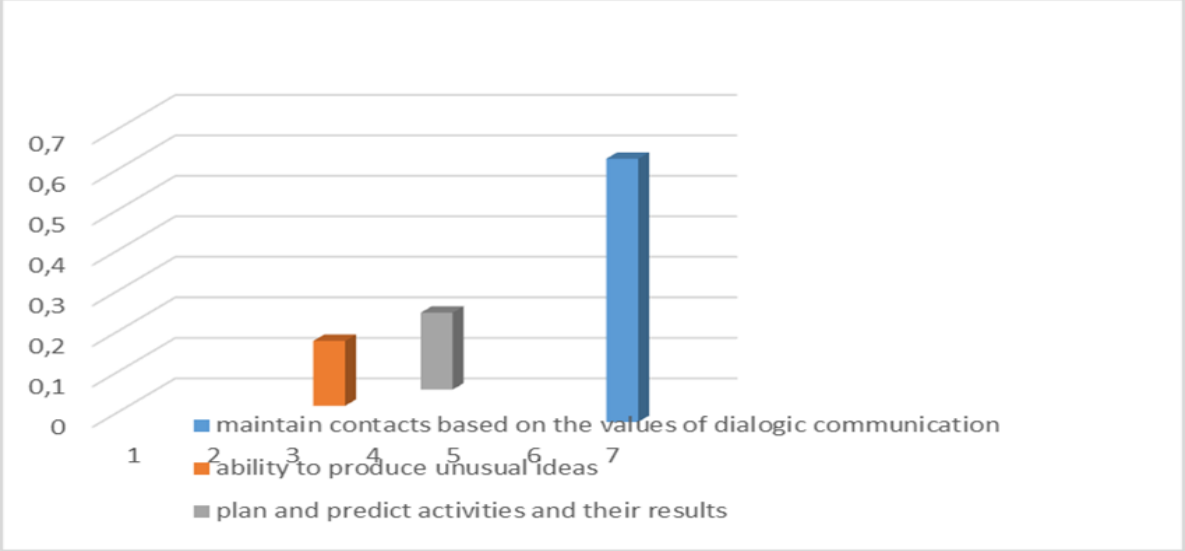

Figure-2. Results of the discussed topic in formation foreign communicative competence (complied by the authors)

According to the results of the discussion by the students of this question, the authors determined that 52% of students showed flexibility that Kazakhstan's accession to the Bologna process will ensure the recognition of Kazakhstani educational programs, curricula, academic mobility of students and teachers, convertibility of domestic diplomas in the European region, the right of graduates for employment in any country. 23% unification of education and control (above all, the test system) creates an opportunity to rote the necessary material, does not dispose to critical thinking and the ability to ask questions instead of choosing answers from a list offered. 25% of students assessed and analyzed that a bachelor's degree is often perceived as incomplete or incomplete higher education, the wage rate with such a diploma is significantly lower even and bachelors are treated less prejudicially.

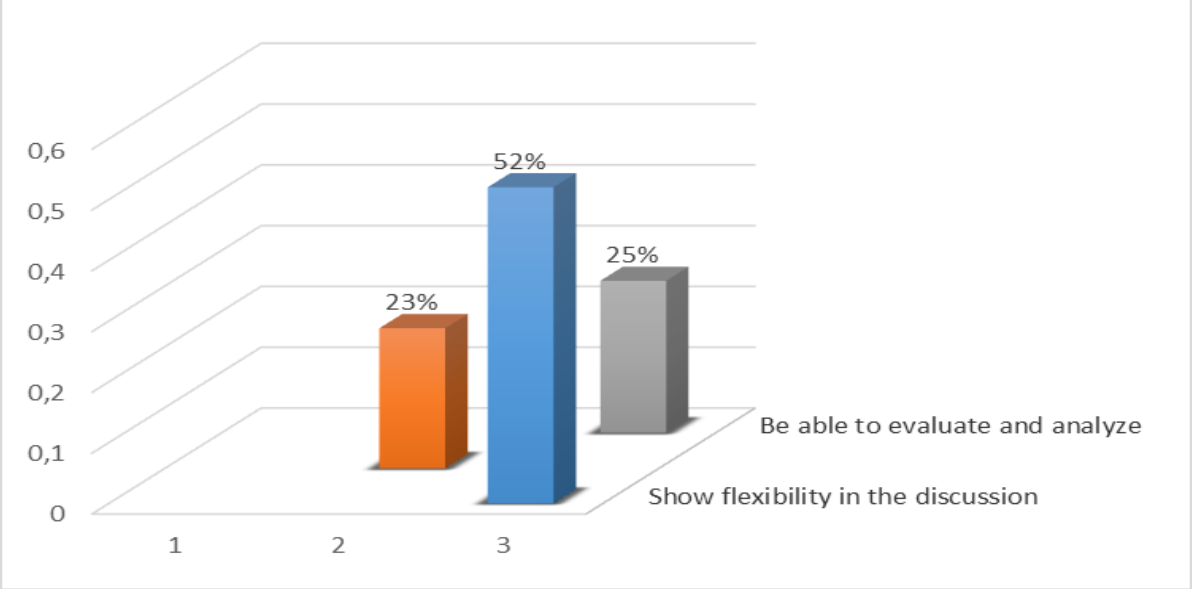

Figure-3. Results of the discussed topic in formation foreign communicative competence. (Complied by the author)

Based on the results of the study, the authors have observed positive trends in all criteria, and improvements in indicators such as argumentativeness, communicativeness, flexibility, originality, and the ability to analyze and self-analyze. This leads us to conclude that discussions in English classes are an effective teaching method that helps to develop foreign language communicative competence in students. Moreover, it generates an undeniable interest among students, both in terms of form and content.

Comparison of the results obtained with the results of other studies. When working on the task, students interact with each other to work out different sentences and expressions, examples of their grammatical and lexical units of language, pronunciation of words. Students focus on solving various problems through the norms of linguistic interaction with the participants in the discussion and, after completing the discussion, have the opportunity to analyze the entire discussion as well as the individual participants and their statements. Consequently, discussion skills develop skills for interaction in professional and learning environments and contribute to the development of communicative competence. The main value of discussion communication is learning to interact.

The analysis of the collected materials allowed us to come to the conclusion that the application of the principles of the search for truth, clarity and acceptability in the process of forming the communicative competence of students using the discussion method is effective. The authors came to this conclusion on the basis of a deep and comprehensive analysis of the linguodidactic requirements for principles, taking into account the methodological possibilities of teaching disciplines. The practical significance lies in the fact that the task developed by us was effectively used in the process of teaching the discipline "Methods of foreign language education".

Therefore, the effectiveness of training discussions was proven in the formation of foreign language communicative competence in English classes, and it is necessary to include such classes in the educational process.

Conclusion

Based on the above, the authors have concluded that, in general, the method of discussion can be utilized to develop the speaking skills of students in a language institute. To achieve this goal, teachers should carefully prepare the material, taking into account the features of this method, the curriculum, the purpose of the lesson, and the topic. Additionally, it would be advisable to build learning cycles in stages according to the level of students' language proficiency in the basic skills of discussion, such as reasoning and argumentation. The use of the "Discussions" method in English classes offers an opportunity to:

- Form both linguistic and speech skills of students

-Train thinking and understanding specialists who are ready for open and constructive dialogue with colleagues from different countries and cultures

-Teach students to create models of scientific research and decision-making that they can apply not only in their professional activities but also in everyday life, in the process of communicating with representatives of other cultures.

In conclusion, the authors note the important role of discussion in the development of students' personalities. With the help of a foreign language, students gain necessary perspective for self-realization and disclosing their creative potential. This method fosters not only students' speech culture but also creates necessary conditions for finding independent solutions to discussed problems, which is a driving force of learning. Using the method of discussion in teaching a foreign language, in addition to improving students' foreign language communication skills, develops their critical thinking and creates conditions for the use of personal life experiences and previous knowledge for assimilation of new ones.

Based on the above, the authors can emphasize that the use of discussion in the study of a foreign language gives students ample opportunities to develop

speech skills, enhance foreign language communication, stimulate interest in the subject, and better absorb lexical and grammatical material. It is appropriate to use discussion at all levels of foreign language teaching because it introduces variety and makes the lesson bright and dynamic.

To summarize, the authors would like to highlight the advantages of using discussion as a method for developing foreign language communicative competence in comparison to using native language discussion in terms of communicative competence development. Learning a foreign language itself disciplines, organizes, promotes logical thinking, and increases self-control. Discussion in any language is a universal means of teaching interpersonal communication. Thus, the discussion method not only fosters a culture of speech, but also encourages students to find independent solutions to the problems discussed which, in turn, a driving force for cognitive activity is. The application of this method in teaching a foreign language forms a culture of creative thinking in students, creates conditions for using personal life experience and previously acquired knowledge to assimilate new information.

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PHILOLOGICAL SCIENCES

COGNITIVE ANALYSIS OF LINGUISTIC RESEARCH IN GENDER DIFFERENCES

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Abstract

This article examines gender differences in vocabulary from a cognitive linguistics perspective. It examines the influence of cognitive processes on the perception and use of language by men and women. It focuses on how different cognitive structures associated with gender identity influence word choice, meaning formation, and interpretation. The article analyzes examples of lexical differences in the speech of men and women, including both referential and metaphorical differences. Conceptual metaphors related to gender and their influence on the lexical content of language are also considered.

Linguistic studies of gender differences in speech practices are an important area of study in sociolinguistics. Research shows that language not only reflects but also constructs gender roles in society. This article examines key aspects of differences in the speech of men and women, their sociocultural determinacy, and their interaction with social structures. The focus is on theoretical approaches to analyzing gender differences, as well as empirical research, including those focusing on differences in vocabulary, intonation, forms of address, and emotional expression in the speech practices of men and women. Stereotypes related to language use and their influence on the perception of social roles in modern society are also discussed.

Keywords: gender differences, sociolinguistics, gender and language, stereotypes, gender identity, speech practices, vocabulary, intonation, sociocultural norms.

Cognitive linguistics, as an interdisciplinary field, considers language as a phenomenon closely related to the processes of thinking, perception, and social structures. One of the most interesting topics in cognitive linguistics is the study of how gender differences affect lexical perception and language use. Gender, as a social and cultural category, permeates all levels of language, from phonetics and grammar to vocabulary and phraseology. Language, in turn, not only reflects gender differences, but also actively shapes ideas about the roles of men and women in society.

Linguistic studies of gender differences occupy an important place in sociolinguistics, as language is one of the main tools through which gender roles and social stereotypes are expressed and consolidated. Language reflects not only the biological differences between men and women, but also the cultural, historical, and social conditions of their interaction. Gender differences in speech practices manifest themselves in various aspects, from vocabulary and grammatical constructions to intonation and communication style. These differences can influence the perception of individuals in society and the formation of stereotypical images of male and female roles [6].

In the field of linguistics, there are several theories explaining gender differences in language. Deborah Tannen, a famous American linguist, in her book "You just don't understand: Women and men in conversation" argues that men and women use different communication strategies, which is related to their social roles: men tend to be more aggressive and competitive in their communication style, while women tend to be cooperative and empathic [5].

It is also important to note the work of Peter Tragor and Robert Lang, who argue that gender differences in language can be seen as the result of broader social and cultural practices, where language serves as one of the tools for maintaining hierarchies in society.

The vocabulary of a language is an important part of its structure, which is closely related to the perception of the surrounding world and to social, cultural and cognitive processes. One of the most interesting aspects in the study of vocabulary is its gender component. Gender, as a social and cultural category, influences the use of words and expressions, reflecting and reinforcing stereotypes about men and women. Language not only reflects social and cultural norms, but also actively forms ideas about the roles that are attributed to different genders in society.

One of the striking features of gender differences in vocabulary is lexical asymmetry, which is expressed in the fact that for men and women there may be different words denoting the same things, but with different stylistic coloring or social meaning. Gender asymmetry also manifests itself in the use of pejorative and exaggeratedly positive terms to describe the behavior of representatives of different sexes. An example is the word "coward", which applies only to women, while there is no similar male equivalent (although the word "coward" denotes male cowardice).

The vocabulary of language is directly related to the perception and interpretation of reality, including the perception of the roles of men and women. Gender stereotypes embedded in language affect how we perceive people and their behavior. For example, in the public consciousness, women are traditionally associated with gentleness, care, and sensuality, while men are associated with determination, strength, and activity. These stereotypes are reflected in the language through the choice of words.

Vocabulary expressing the traditional perception of women's roles: Women are often described using words such as "gentle", "caring", "weak", "sweet", which reinforces the perception of them as dependent, emotional, and subordinate beings. These words can have an impact on how society perceives a woman as a

member of society, whose actions and decisions are most often determined by emotional and caring aspects.

Vocabulary expressing the perception of men's roles: Unlike women, men are more often associated with qualities such as "strength", "leadership", "aggression", "confidence". These words reinforce the stereotypes that men should be determined, capable of action and overcoming difficulties. It also influences the perception of a man's social role as an active participant in external life, in contrast to a woman, whose role is often associated with household duties.

In the professional field, there are also gender differences in vocabulary, which can reflect and reinforce social expectations related to gender. In a number of professions, there is a pronounced gender asymmetry in terminology. For example, terms such as "director", "general manager", and "supervisor" are often used for men in leadership positions, while women in similar positions are often designated with added gender clarification, such as "female director" or "director", which emphasizes exclusivity and the rarity of such a situation. This may help reinforce the stereotype that men should occupy leadership positions "by default".

Vocabulary plays a key role in distinguishing between male and female language practices. Research shows that men and women often use different lexical tools to describe the same phenomena. For example, Goldberg G.L. in the study "Language and Gender" notes that women are more likely to use words expressing emotion and empathy, while men are more likely to use words related to actions and achievements. This observation is related to the cultural norm according to which women are expected to be emotional, while men are expected to be rational and in control [3].

In addition, there is the phenomenon of "women's vocabulary", which includes smaller, more detailed words describing everyday life, feelings, and relationships. An example is the large number of words in Russian to describe different shades of color or states of mind that women use more often.

From the point of view of cognitive linguistics, the use of language is associated with conceptual schemes that form the basis of human thinking. These schemas, or schematic models, are generalized representations of the world that are formed through experience and social interactions. Gender differences in language are often associated with differences in the cognitive schemas that men and women use in the context of communication.

For example, conceptual metaphors such as "life is a journey" or "life is a struggle" may be perceived differently by men and women. Men, who are traditionally more focused on competition and achievement, may more often use metaphors related to struggle, victory, and strength, while women, who are focused on caring and maintaining relationships, may use metaphors related to travel or the process of becoming.

One of the key topics of the study is the analysis of lexical differences in the language of men and women. Vocabulary, as a well-known element of language, often reflects sociocultural expectations and stereotypes related to gender. In the speech of women, one can often observe a higher frequency of using words expressing emotions, feelings and care, while men are more likely to use words related to actions, achievements, and results.

An example of such a difference can be a comparison of the vocabulary used by women and men to describe interpersonal relationships. Women are more likely to use words such as "caring", "love", "empathy", while men are more likely to use words related to "competition", "success", "strength". This does not always mean that women and men cannot use these words, but research shows that their frequency and context of use may vary depending on the social and cultural context.

In cognitive linguistics, special attention is paid to the analysis of conceptual metaphors that underlie our thought processes. Gender metaphors are one of the clearest examples of such conceptual differences. For example, in Russian there are metaphors reflecting the idea that a woman is the "weaker sex" and a man is the "stronger sex". This metaphorical representation is deeply ingrained in the language and influences the perception of the social role of each of the sexes.

Conceptual metaphors can also be associated with the perception of emotions and behavior. For example, the female emotion of love is often metaphorically represented as "fire" or "river", while for men, love can be associated with "struggle" or "high purpose". This reflects differences in social roles, where women are often assigned emotional and caring roles, while men are assigned rational and achievement roles.

One of the most striking examples of gender metaphors is the idea of a "weak" and a "strong" gender. The metaphor of "a woman as the weaker sex" is deeply rooted in culture and language, associating women with vulnerability, dependence and subordination. At the same time, "man as the stronger sex" presents men as a symbol of power, independence and strength. These metaphors, on the one hand, reflect traditional ideas about men and women, on the other hand, they strengthen and support these stereotypes [3].

Women are characterized by metaphors related to fragility and vulnerability. For example, metaphors such as "crystal vessel", "delicate flower", or "angel's wing" emphasize the physical and emotional fragility of women. This affects the perception of women as weak and in need of protection, which, in turn, shapes a woman's social role as a caring but dependent person.

Men are more often associated with metaphors related to power, control, and achievement. For example, the metaphor "man as a leader" or "man as a defender" emphasizes the dominance of men in public and social life. The metaphor "love as war", which is also often used in relation to men, traces the idea of struggle, conflict and victory. Men are perceived as those who fight and overcome difficulties, which corresponds to traditional male roles in society.

Gender metaphors are found in different languages. For example, such metaphors as "man of steel", "the boss", and "the protector" are common in English. These metaphors actively form the idea of men as strong and domineering personalities. In contrast, metaphors such as "fragile beauty" or "emotional creature" are often applied to women, emphasizing their vulnerability and emotionality.

An interesting example is the Chinese metaphor "a woman is like water", which emphasizes the softness, flexibility, and malleability of women. While "a man is like a stone" symbolizes strength, rigidity and constancy. This metaphor embodies broader cultural concepts of male and female roles in Chinese society, where men are traditionally perceived as support and protectors, and women as supportive and caring individuals.

Metaphors play an important role in shaping the public perception of men and women. They not only reflect existing gender stereotypes, but also actively reproduce them. Metaphors create images that influence behavior and expectations from people based on their gender. For example, the metaphor of "war" to describe a love relationship can create an image of aggression and conflict, which helps reinforce the stereotype that men should be aggressive and competitive. The metaphor of "weakness" in relation to women supports the stereotype that women should be dependent and caring, as well as vulnerable.

These metaphors also influence an individual's sense of self and behavior in society. Women who often encounter the metaphor of "tenderness" may perceive themselves as needing protection and care, which affects their behavior and perception of their abilities. Men, in turn, are confronted with the metaphors of "strength" and "leadership", which creates an expectation for them to achieve success through overcoming difficulties and demonstrating their strength.

An example of lexical differences that can also be explored through the lens of cognitive linguistics is the use of spatial vocabulary. Men and women perceive space differently and often use different metaphors to describe objects and actions related to spatial landmarks. Women tend to use metaphors focused on connection and satisfaction of needs, whereas men may more often turn to metaphors related to the acquisition or control of space [1].

Research shows that men and women often use space and spatial vocabulary in different ways, which may be related to their social roles and cultural expectations. Spatial metaphors and expressions not only reflect reality, but also help to form and strengthen certain social norms and gender stereotypes. For example, metaphors that associate men with spatial activity (for example, "occupy space", "conquer the world") emphasize their role as leaders and agents of power, while metaphors that associate women with limitations in space (for example, "limited freedom", "locked in a house"). They reinforce stereotypes about women's subordination and dependence.

Spatial vocabulary often serves as a reflection of social norms and stereotypes. Gender differences in the use of spatial vocabulary can be viewed through the lens of cognitive schemas, which are mental structures that help people perceive and interpret the world around them. For example, for women, it is traditionally assumed that their role in society is related to home and family, which can be expressed in the use of metaphors that emphasize the limitations of their "space". In turn, men are often associated with wider and more open spaces, reflecting their traditional role as leaders and agents of external change.

Men and control over space: Spatial metaphors such as "conquer territory", "be on top", "occupy space" are actively used to denote male control over the social or physical environment. These metaphors not only reflect male activity, but also symbolize power and dominance [2].

Women and limited space: Women, in turn, are often associated with spatial metaphors associated with restriction and lack of freedom. For example, the metaphors "shackled space", "locked in a cage", "secondary place" are used to describe the limitations in choice for women. These metaphors reinforce stereotypes that a woman's place is in the home, not in public or political life.

Gender-related stereotypes also have an impact on lexical behavior. Women are often perceived as more emotional and less aggressive in their speech, which is associated with cultural stereotypes about "feminine" gentleness and caring. This, in turn, affects the choice of vocabulary and intonation. Men, on the contrary, are more likely to use aggressive or competitive words, reflecting traditional expectations of "male" determination and strength.

Intonation and other paralinguistic tools also play an important role in gender differences. Women tend to use a more diverse intonation, which is related to their social role in society, where they are often expected to show emotion and expressiveness. Men, in turn, may tend to have a more even, monotonous intonation, which is associated with restraint and control.

Stereotypes about the "feminine" and "masculine" language often lead to negative perceptions of the speech of both sexes. Women who use a "masculine" communication style may be perceived as aggressive or unfeminine, while men who are prone to a "feminine" style risk being perceived as weak or dependent. These stereotypes have a great impact on public perceptions and gender roles in communication.

Linguistic studies of gender differences in speech practices show that language is not only a means of communication, but also an important tool for shaping and maintaining gender roles in society. Differences in the speech of men and women are related to cultural and social norms, which, in turn, affect the perception and distribution of power and status in the social structure [4].

Cognitive linguistics offers a unique approach to the study of gender differences in language, as it allows not only to analyze language as a system of signs, but also to consider it in the context of cognitive processes, social norms and cultural expectations. Gender differences in vocabulary are not accidental; they are deeply rooted in cognitive schemas, social roles, and metaphorical models that men and women use to perceive the world.

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THE SEMANTIC-PRAGMATIC ROLE OF DETERMINERS IN ENGLISH

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Abstract

The present article is devoted to the semantic-pragmatic role of determiners in English. Determiners play a key role in syntax, semantics and pragmatics, creating not only the structural relations between words, but also the communicative intentions of speakers and the interpretive processes of the hearers. Their role in a sentence serves to expand the structure of a sentence. Pragmatically determiners are the components of communicative competence. In linguistics the study of determiners from semantical and pragmatical point of view is of great importance. Here a great attention has been given to the determiners that function as adjectives and adverbs. A sentence can be expanded through several determiners and express different meanings.

The main functional indicators of determiners are: their use at the beginning of a sentence and their compatibility with various structural schemes of a sentence.

In writing, determiners are independent, while in oral speech they are separated by intonation.

Keywords: semantic, pragmatic, determiners, predominator, referential properties.

1. INTRODUCTION

In the middle of the 20th century, the study of syntactic structure underwent a significant transformation. Researchers began to examine not merely the formal arrangement of sentence constituents, but also the deeper functional mechanisms by which sentences expand and become communicatively more complex. One of the central points of focus became freely adjoining constructions - determinants or determiners. Their role in a sentence construction extends far beyond simple grammatical marking.

In the 1950s, it was noted that expanded sentences include secondary elements, like adverbs of time, place, reason, purpose, concession and condition, which do not directly connect to the subject or predicate. These elements often affect the entire sentence, adding meaning like presupposition, emphasis, relevance, and the speaker's attitude.

The topic of determiners has been actively developed in world linguistics. Considering that determiners are among the smallest influential syntactic units, their study is crucial for understanding. Its meaning is constructed in speech, writing and language acquisition. Determiners shape the referential structure of discourse, encode speaker's assumptions, and guide the hearer's inferential process.

The current research reveals and explains the types of determiners in English and the diverse meanings they express in real communicative contexts. We will try to examine the semantic-pragmatic nature of determiners and offer our own theoretical interpretation of their functioning.

The aim of this article is to reveal the features of the development and functioning of determiners in English, with special reference to their semantic-pragmatic roles in discourse. We attempt to clarify how determiners – (mailny the adjectives and the adverbs) encode speaker stance and influence the interpretation of utterances.

The object of this study is the identification and semantic-pragmatic investigation of determiners in modern English and the determination of their communicative position within the sentence.

2. RESEARCH METHODOLOGY

The research employs descriptive and cognitive-pragmatic methods. Description is used to identify determiners in everyday speech contexts, while cognitive-pragmatic analysis explains how determiners guide meaning interpretation in discourse.

In this article the adjectives and the adverbs functioning as determiners are examined systematically with regard to:

– their role in context;
– their deictic and referential properties;
– the speaker's evaluation;
– their role in presupposition, specificity and emphasis.

The role of determiners in context is closely connected with their deictic and referential properties. These properties help to convey meaning by specifying the noun they precede. Understanding the deictic and referential roles of determiners helps us make sense of how they shape the meaning of sentences in real-time. In speech a speaker evaluates the context, the relationship with the listener and their intention to choose the appropriate determiner (1).

In presupposition determiners like '*the'* presuppose the existence of the referent. '*The'* signals specificity, while '*a'* signals non-specificity, while the demonstratives '*this', 'those'* can specify temporal reference. Speaking about emphasis the determiners can highlight specific elements, like '*the'* to elevate importance, or quantifiers '*all', 'only'* to emphasize quantity or uniqueness.

3. MATERIALS OF THE RESEARCH

Determiners in Linguistic Research

The English term 'a determinant' or 'a determiner' refers to the words that identify, limit or specify the referent of a noun. L.Bloomfield was the first to introduce this term into linguistic theory, classifying determiners as restrictive adjectives, while determinative words are treated as a separate functional category, too. In contemporary linguistics many scholars regard determiners as neither adjectives nor adverbs, but as a distinct category of functional, pragmatic markers.

Although determiners share features with nouns (e.g. indicating number, person or possession), unlike

adjectives they do not describe qualities rather, they encode referential, contextual and pragmatic information. Thus, the determiners become a key device for information management in discourse.

In English certain adjectives and adverbs function like determiners when placed before a noun or an adjective. Words like *very*, *extremely*, *quite*, *only*, *just*, *such* and *certain* express intensification, limitation, evaluation or intended vagueness.

Ex.: a certain writer – means controlled vagueness;

only five scienists – shows exclusivity;

quite a difficult problem – indicates the evaluation of the speaker;

very old city - gives emotional emphasis.

These elements do not add descriptive content alone, they shape how the message should be interpreted, indicating the speaker's attitude.

The use of adjectives and adverbs as determiners in a sentence is one of the most common issues in English. Both adjectives and determiners are used in front of the word they define, describing it. However, there are certain differences between adjectives and determiners. Most adjectives are used both before and after a noun. A determiner can only be used in front of a noun. However, there are no restrictions on adjectives used in front of a noun. According to some grammarians, determiners are a component of adjectives. Let's look at the difference between adjectives and determiners:

Adjectives	**Determiners**
They can be used in the function of a predicative.	They cannot be used after a noun and do not have any syntactic function.
They have comparative and superlative degrees.	They do not have a degree category.
They can be placed before a word in a sentence.	They cannot be used before a word in a sentence.
Several adjectives can be used before a noun.	Only one determiner can be used before a noun.
There are many adjectives in the language.	The number of determiners in the language is limited.

Most of the determiners are always used either in the front position or after the predicate. Therefore, they are almost as important elements in the construction of the sentence as the predicate and the subject.

The determining connection is the creation of syntactic connections by combining word forms in a sentence. The determinant plays an important role in the semantic structure of the sentence. In many cases, it indicates the semantic subject and object as the main component.

N.Y. Shvedova notes that determiners serve to expand the sentence by being used within word combinations, while not defining any sentence member separately. She indicates the following types of adverbial determinants:

1) local
2) temporal and temporal-quantitative
3) cause-effect
4) purpose
5) manner-action [6, 181].

The position of determiners at the beginning of the sentence varies. If the determiners comes in the front position in the sentence, it becomes a rheme in the sentence.

Determiners are added to both simple and complex sentences. Sometimes a sentence is expanded due to several determiners. The grammatical position of determiners in the sentence is mainly at the beginning of the sentence, but their position may change in the actual composition of the sentence.

Determiners are the reality of the language, they have specific features both in terms of content and in the expression of thought. According to Shvedova, determiners belong to the entire sentence (6, 190). However, studies show that when the adverbs "here" and "always" perform the adverbial function in a sentence, they belong not to the entire sentence, but to the verb. For example: /Here he is apploaded//. In the sentences /He is always apploaded//, "here" and "always" belong not to the sentence as a whole, but to the noun. This situation is also evident in Azerbaijani. /They love him here//. /They always love him//.

Traditionally adjectives and adverbs do not function as determiners in grammar, they can play roles as determiners in specific contexts. Adjectives often provide descriptive or modifying information about a noun (e.g., *big hall*, *beautiful rose*), they can sometimes take on the role of a determiner, especially in cases of attributive adjectives or limiting adjectives.

Adjectives like *certain*, *another*, *few*, *many*, *both*, *several*, etc., semantically limit the range of possible reference for the noun. These adjectives can specify which instance of the noun is being referred to, much like determiners. Example: *Both students* (the adjective limits the noun "students")

Many students (the adjective limits or quantifies the noun "students")

The use of limiting adjectives is not just a semantic decision, but a pragmatic one (2, 347). The speaker might choose a limiting adjective based on the context or the information they want to convey. For instance, *some* in "some people knew the solution of the problem" could imply that the speaker knows exactly who those people are.

In discourse, speakers might use a determiner-like adjective to narrow down their statement based on shared knowledge or assumptions. For instance, "this specific idea" implies the speaker and listener have mutual knowledge about the idea in question.

Adverbs are typically used to modify verbs, adjectives, or other adverbs (e.g., *quickly*, *very*, *fast*). However, in certain constructions, they can take on a determiner like role, especially in quantification or degree.

Degree-modifying adverbs can serve to quantify or specify a noun phrase indirectly. For example, adverbs like *much*, *more*, *less*, *several*, and *all* can modify nouns in ways that resemble determiners.

Example: *Much information* (The adverb *much* is used in a way similar to a determiner, indicating quantity of the noun "information.")

More people (*more* functions in a determiner-like role by modifying the noun "people").

Analysing pragmatic classification of determiners the following groups of determiners are proposed:

1) Determiners of definiteness or presuppositional determiners: the definite article (*the),* demonstrative *(this, that, these, those),* possessive *(my, her, Jim's, each other's),* interrogative and relative *(which, what, whichever)* pronouns.

2) Indefinite determiners. Here are included the indefinite article (*a / an),* and *indefinite pronouns (some*, *any).* These determiners show whether the listener can identify what is being referred to.

3) Quantifying determiners - *many, much, few, little*, comparative and their superlative forms of adjectives and adverbs, intensifiers (*very, too, so*). They express the speaker's evaluation of quantity, often pragmatic rather than numerical.

4) Group quantifiers. Words such as *a lot of, plenty of, a bit of, a number of* carry subjective estimations and pragmatic vagueness.

5) Numerals as determiners. The numerals (*one, four, eight)* also operate pragmatically when expressing precision or contrast.

6) Person-denoting determiners. In combinations like *we citizens, you guys*, etc. personal pronouns situationally specify the referent group.

7) Exclamatory determiners like s*uch*, *what* express emotional evaluation.

8) Determiners like constructions: *what size, this colour, how many* function pragmatically as categorical frames that guide the hearer's expectations.

The main pragmatic function of determiners is to expand the structure of the sentence, influencing topic–focus relations. When determiners appear in front-position, they often become the rheme, carrying new or emphasized information.

As it is known determiners may belong not to individual sentence members, but to the sentence as a whole, contributing to the pragmatic orientation of the utterance.

There are determinative connectors that create syntactic links, but their deeper role is pragmatic: they help speakers signal relevance, mark contrast, indicate perspective and manage discourse cohesion. A sentence may be expanded through multiple determiners, each contributing a different pragmatic layer, because determiners express functions, such as definiteness, deixis, specificity, possession, quantification, comparison, and negation, they guide how information is understood.

4. Literature Review

The study of determiners has a long-standing history in linguistics, beginning with early structuralist works and continuing into modern functional, cognitive and pragmatic frameworks. The conceptual foundation for determiners as a linguistic category was established by an american linguist L.Bloomfield, who first introduced the term "determinant" to describe restrictive elements that limit or specify the noun (2, 353). He classified determiners as a subset of adjectives, distinguishing between descriptive and restrictive adjectives, the latter functioning as determiners. L.Bloomfield's structural approach treated determiners as morphological units, not as communicative devices.

Later some scholars expanded the notion by including adjectival pronouns under the label "determinatives," emphasizing their functional rather than descriptive nature.

The functional approach gained prominence with the work of Ch. Fries, W. Francis and P. Roberts, who rejected the classification of determiners as adjectives and argued instead that they represent a distinct class of functional words. This view laid the groundwork for understanding determiners as units that operate at the intersection of syntax and semantics, though pragmatic considerations remained peripheral.

Modern Western linguistics increasingly recognizes determiners as primarily pragmatic operators. The scholars indicate the determiners as markers of definiteness, deixis, specificity and referential status. Recent studies in cognitive linguistics have further expanded this perspective, demonstrating that determiners play a crucial role in mental representation and conceptualization. Intensifiers (*very, extremely*), limiters (*only, just*), and approximators (*some, certain*) are now seen as markers of speaker stance and epistemic commitment, confirming the need for a pragmatic approach to their analysis.

The literature reveals a shift from purely grammatical descriptions toward broader semantic and pragmatic interpretations of determiners. This transition underscores the importance of studying determiners not only as structural components, but as communicative tools that shape meaning, manage reference, and structure discourse.

Effective use of determiners in socially sensitive contexts signals pragmatic competence, a key component of communicative competence (3, 272). Learners who understand how determiners function pragmatically can better navigate social norms, express needs courteously.

According to Leech "pragmatic competence involves not simply knowing what can be said, but knowing what *should* be said in a given context" (5, 124).

In pragmatics, the choice of adverb (or limiting adjective) like *all*, *some*, or *many* can convey subtle meanings about what the speaker assumes or knows about the listener's understanding of the world.

According to Quirk et al. determinatives or determiners are the words that determine the noun phrase. Determiners can express both definite and indefinite reference in discourse and according to their position in the noun phrase they have three types: predeterminer, central determiner and postdeterminer.

Predeterminers are used before specific central determiners and give additional information about quantity or specificity, e.g.: both, half, such, etc. According to the lexical meaning and grammatical use they have four categories: 1) all, both, and half;

Example: a. <u>All</u> students are at the meeting. (*all* functions as a determiner) b. <u>All</u> the students are at the meeting. (determiner) c. <u>All</u> of the students are at the meeting. (pronoun) d. Where are the students? - <u>All</u> are

at the meeting. (pronoun) e. They are all at the meeting. (pronoun).

2) the multipliers: double, once, four times, etc.;

a. And how often do you get up early in the morning? b. About four times every week. a. How many times do you visit your native country? b. Two times each year.

3) the fractions: two-third, one-seventh, etc. I have just finished reading one-fifth (of) the book that was given me.

4) such, what.

e.g.: It was such an amazing film (7, 238).

This, that, some, any, no, etc. are central determiners and share the same use and function as articles. However, based on Quirk et al.'s research, central determiners form a set of closed-class items that are mutually exclusive with each other, which depicts the central determiners' nature of independence. They can only occur in a "choice relation", once in front of a noun instead of another to provide not only the determinative status, but lexical meaning with those except articles. e.g. a train, this train, but we cannot say *a some train, the a train.* The definite article *the* and the indefinite articles *a/an* are widely considered to be the central determiners that are most frequently used. These determiners do not possess any lexical meaning and do not serve any purpose on their own without being in association with the noun that follows them. Their primary function is to establish whether the noun they determine should be interpreted as definite or indefinite (7, 234).

Postdeterminers are those that are placed right after the central and predeterminers. Here are included cardinal, ordinal and general ordinals, quantifiers.

The postdeterminers *much and many* in both contexts are typically used in nonassertive sentences, in other words, in questions or sentences with negative meanings and subsequently the postdeterminer *a lot of or lots of* is used in assertive or an affirmative sentences.

When it comes to language, determiners are crucial, because they provide significant context for the nouns they modify. Determiners are important in noun phrases because they help specify the head of the noun phrase. They are like linguistic markers that help to accurately interpret the intended message. For example, the sentences "I saw boy" and "I saw the boy." The addition of the determiner "the" makes the second sentence clearer, because the addition of "the" refers to a particular boy.

5. CONCLUSION

The results of the study have a theoretical value for both general and applied linguistics. Understanding determiners from semantic-pragmatic perspective enriches the teaching of English grammar. The correct use of the determiners depends on the contextual awareness and the communicative competence, but not on syntactic rules alone.

The primary function of the determiners is to establish the referential, informational and interpretive framework within which the noun is understood. Determiners expand the sentence, shape discourse coherence, encode shared knowledge, and express the speaker's viewpoint. Thus, they must be understood not simply as grammatical devices, but as semantic-pragmatic instruments essential to meaningful communication.

As adjectives and adverbs are traditionally not considered determiners, they can take on determiner-like roles through their semantic and pragmatic functions. Adjectives often act as limiting or qualifying modifiers of nouns, and in certain cases, adverbs can modify nouns in ways that resemble determiners, particularly in terms of quantity or degree.

In both cases, pragmatics plays a significant role: the meaning and function of these words depend heavily on context and speaker intent, making their use in the role of determiners dynamic and often context-dependent.

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ПРАГМАТИКА БЕЗЛИЧНЫХ КОНСТРУКЦИЙ В ФАТИЧЕСКОМ ДИСКУРСЕ РУССКОГО И БОЛГАРСКОГО ЯЗЫКОВ

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PRAGMATICS OF IMPERSONAL CONSTRUCTIONS IN THE PHATIC DISCOURSE OF RUSSIAN AND BULGARIAN LANGUAGES

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Аннотация

Статья посвящена исследованию прагматики безличных конструкций в фатическом дискурсе русского и болгарского языков, с акцентом на их функции смягчения высказываний и регулирования межличностного взаимодействия. Сопоставительный анализ показывает существенные различия: в русском языке широко употребляются безличные формы, тогда как в болгарском – преимущественно личные глагольные конструкции. Исследование демонстрирует интеграцию синтаксических, прагматических и культурно-ментальных аспектов языковой системы и подчеркивает их значение для понимания национально-специфической концептуализации социальных и психологических реалий.

Abstract

The article is devoted to the study of the pragmatics of impersonal constructions in the phatic discourse of Russian and Bulgarian, with a focus on their functions in mitigating statements and regulating interpersonal interaction. A comparative analysis reveals significant differences: impersonal forms are widely used in Russian, whereas personal verb forms predominate in Bulgarian. The study demonstrates the integration of syntactic, pragmatic, and culturally mental aspects of language and emphasizes their significance for understanding the nation-specific conceptualization of social and psychological realities.

Ключевые слова: безличные конструкции, фатический дискурс, русский язык, болгарский язык, межличностная коммуникация, прагматика, культурная когниция.

Keywords: Impersonal constructions, Phatic discourse, Russian language, Bulgarian language, Interpersonal communication, Pragmatics, Cultural cognition.

Прагматика безличных конструкций является важным аспектом исследования фатического дискурса в русской и болгарской языковых традициях. Языковое отражение менталитета носителей языка демонстрирует особенности восприятия действительности, способы интерпретации социальных взаимодействий и стратегии коммуникативного поведения. В частности, безличные предложения выполняют функцию смягчения категоричности высказываний и обеспечивают тактическую нейтральность в межличностном общении. Исследование прагматических особенностей данных конструкций позволяет выявить закономерности их использования в различных коммуникативных ситуациях. В рамках анализа особый исследовательский интерес представляет несимметричность функционирования безличных конструкций, выступающая значимым показателем корреляции между языковыми механизмами и менталитетом языкового сообщества. Таким образом, обращение к безличным конструкциям как прагматическому средству коммуникации неизбежно приводит к рассмотрению менталитета носителей языка, поскольку именно он во многом определяет выбор языковых средств и моделей речевого поведения. Менталитет определенной нации отражается в языковой картине мира, обусловливая специфические особенности речевого поведения носителей языка. Особенности ментального склада, внутренние импульсы, отражающие глубинные свойства психики языковой личности, предопределяют её языковые предпочтения и особенности речевого поведения.

В последние десятилетия тема менталитета и его отражения в языке привлекает значительное внимание исследователей. Говоря о русском языке, следует отметить, что в нём преобладают конструкции, способствующие смягчению категоричности высказываний. Это объясняется стремлением носителя русского языка не вторгаться в личное „я“ собеседника, когда речь идёт о слушающем и его поступках, поскольку люди, как правило, не терпят безапелляционного вторжения в свой мир. Тот же фактор объясняет наличие в русском языке множества синтаксических конструкций, употребление которых помогает избежать конфликта и наладить коммуникацию. В этой функции широко применяются безличные предложения, в которых форма сказуемого не выражает лица, то есть процесс или состояние не соотносится с субъектом или активным деятелем [8, с. 64].

В современных исследованиях подчёркивается, что безличные предложения широко употребляются в русском языке и представляют собой

наиболее разнообразную по структуре и семантике разновидность русских предложений. В лингвистике постоянно отмечается тенденция их роста и всё более широкого распространения в современном русском языке – количество и частотность употребления таких конструкций неуклонно увеличиваются. Это объясняется тем фактом, что лексическое наполнение своеобразных грамматических шаблонов, формирующих их, постоянно пополняется новыми формами. В качестве таких шаблонов выступают как специализированные формы безличности, так и конструкции, выражающие специфическую семантику – стихийное, независимое от деятеля действие или стихийное, независимое от пациенса состояние. Исследователи данной категории указывают на постоянное расширение словарного состава, способного выполнять эту функцию. Язык не стремится отказаться от такого способа реализации представления о действительности, напротив, он укрепляет его позиции. Для сознания носителей русской культуры, русского видения мира и русского языка важно культивировать и развивать «безличное» восприятие и отражение бытия [16].

Явление безличности в русском языке отражает особенности восприятия мира и способов концептуализации событий, которые не поддаются человеческому контролю или разумению. Богатство и разнообразие безличных конструкций демонстрируют, что язык поддерживает преобладающую в русской культурной традиции тенденцию рассматривать мир как совокупность неконтролируемых явлений, часто воспринимаемых как неблагоприятные: «эти события, которые человек не в состоянии полностью управлять, чаще бывают для него плохими, чем хорошими. Как и судьба» [6, с. 75–76]. Такая ориентация проявляется в ключевых понятиях русской культуры — душа, судьба, тоска, которые накладывают отпечаток на эмоциональность, иррациональность, неагентивность и нравственные ценности, что в конечном счёте обусловливает широкое распространение безличных конструкций.

Статистические данные показывают, что безличные предложения составляют лишь часть синтаксического комплекса русского языка и не доминируют полностью: на их долю приходится около 15 % всех форм в пословицах XVII–XX веков, тогда как агентивные конструкции встречаются в два раза чаще [18, с. 65–75]. Тем не менее, анализ показывает, что безличные формы служат не просто синтаксическим инструментом, но отражают культурные и когнитивные особенности русскоязычного сообщества.

Безличность также выявляет различия между русским и английским языками: в английском действия и ответственность приписываются субъекту, тогда как в русском они часто представлены как безличные, а индивидуум растворён в коллективе, природе или стихии, что отражает коллективистский и фаталистический менталитет [19, с. 528–529]. При этом грамматические особенности русского языка – флективная и синтетическая структура, падежная система, постфикс –ся, слабое использование пассивного залога и относительно свободный порядок слов — также способствуют формированию и употреблению безличных конструкций (Гофман, Электронный ресурс).

Таким образом, безличные конструкции представляют собой комплексное явление, одновременно отражающее менталитет, культурные ценности и типологические особенности русского языка, что делает их предметом интенсивного исследования в современной лингвистике [6].

В болгарской лингвистической литературе безличные предложения рассматриваются как важная категория синтаксиса [17; 13; 15; 5]. А. Атанасов изучает специфику безличных предикатов в ряде статей [1; 2; 3], а З. Минчев уделяет внимание проявлениям категории имперсональности, тесно связанной с безличностью [9; 10; 11; 12]. По его мнению, имперсональность проявляется через отсутствие сознания о собственных или чужих переживаниях, снижение ответственности и активности [11; 12].

Исследователь описывает национально-специфические транскультурные сценарии концептуализации имперсональности. Первый сценарий связан с отсутствием осознанного восприятия действий и относится к первобытному мышлению; природные безличные глаголы типа *смарчава се, вали, облачно е* отражают простое односоставное суждение и отсутствие информации о сознательном источнике действия. Второй сценарий охватывает ситуации, при которых субъект не проявляет активности — психологические безличные глаголы (*спи ми се, мързи ме*) обозначают неподконтрольное человеку состояние, вызванное внешней силой. Выделяются несколько типов таких глаголов: а) исконно безличные с винительным субъектом (*мързи ме, доядява ме*), обозначающие неактивность и невозможность контроля; б) исконно безличные с дательным субъектом (*призлява ми, додява ми*), с аналогичной функцией; в) производные от личных глаголов с дательным субъектом и возвратным элементом (*спи ми се, ходи ми се*), отражающие неактивность и отсутствие ответственности; г) предикативы типа *грях ме е, срам ме е*, указывающие на наличие моральной обязанности; д) предикативы *не ме е еня, не ме е грижа*, фиксирующие отсутствие ответственности; е) предикативы *добре ми е, мъчно ми е, рано ми е, шумно ми е*, выражающие оценку состояния без возможности контроля; ж) предикатив *не ми е до това*, отражающий отсутствие желания действовать или обсуждать. По мнению исследователя, такие конструкции характеризуют пассивность и фатализм болгарской языковой картины мира, что подтверждается примерами из произведений Хр. Ботева, Ел. Пелина, Й. Йовкова, а также болгарскими пословицами: *Преклонената глава сабя не я сече*, *Много хубаво не е на хубаво*, *Трай, бабо, за хубост* и др. Третий сценарий связан с отсутствием ответственности и употреблением социальных безличных глаголов в разных контекстах: неподтвержденный факт (*говори се, че*), констатация или упрёк (*това палто е изцапано*, *тук е пушено*), установление правила (*тук не се пуши / пу-*

шат цигари) и дипломатическое высказывание (*работата, която се върши тук…*). Четвёртый сценарий включает модальные безличные глаголы (*трябва е, налага се, може, случва се, предполага се*), которые выражают низкую степень имперсональности [12, с. 215–227].

Безличные конструкции занимают важное место в фатическом общении носителей русского и болгарского языков. Они широко употребляются при обсуждении типичных для фатики тривиальных тем, таких как погода и здоровье, а также при выражении побуждений, приветствий, прощаний и комплиментов. Такие конструкции встречаются как в жанрах, способствующих улучшению межличностных отношений, так и в жанрах, потенциально ухудшающих коммуникацию.

Использование безличных конструкций позволяет говорящему скрывать свою активную позицию, предоставляя возможность применять разнообразные речевые стратегии для реализации коммуникативных намерений. Особенно характерна тактика побуждения адресата: в побудительных предложениях безличные формы позволяют избежать прямого вторжения в эмоционально-волевую сферу собеседника, одновременно опосредованно апеллируя к необходимости совершения действия, к которому адресат побуждается: - ***Нельзя ли, по крайней мере, хоть это выяснить?*** *-Это-то уж точно нельзя, - покачал головой Мышкин (Белоусова);-**А нельзя ли зажечь лампу?** - спросил Рудольфи. - К сожалению, не могу этого сделать, - отозвался я, - так как лампочка перегорела, а другой у меня нет (Булгаков); - Като дете имах ревматизъм. Понякога…* - ***Тогава не трябва ли да спрете пушенето?*** *(БНК);-* ***В такъв случай не трябва ли да тръгваш?*** *- Имам достатъчно време. (БНК).*

При реализации данного тактического хода наблюдается **несимметричность безличных конструкций** в русском и болгарском языках. В русском языке **безличные конструкции** позволяют избежать несвойственного менталитету подчеркивания активной роли субъекта действия, тогда как в болгарском языке делается акцент на **личной ответственности** исполнителя каузируемого действия. Характер запрашиваемого действия не всегда предполагает его выгодность для адресата, поэтому получаемое сообщение, как правило, имеет **имплицитный характер.**

Таким образом, используя **безличные конструкции,** носитель русского языка снижает категоричность суждения, придавая ему оттенок разъяснения целесообразности подчинения каузируемому действию**. Тактика разъяснения целесообразности,** выраженная через безличные конструкции в болгарском языке, чаще всего реализуется в инструкциях, руководствах или предписаниях: *Съответните дискове* ***трябва да се продават*** *само в региона, за който са лицензирани; Неравномерно или прекомерно загряване* ***трябва да се избягва****; Затова* ***не трябва да се консумират*** *заедно (БНК).*

Употребление безличных предложений может рассматриваться как **тактический прием**, цель которого заключается в привлечении внимания адресата к объективно обусловленным потребностям инициатора сообщения. Такие конструкции используются для **получения поддержки со стороны собеседника** в реализации предполагаемого действия: - ***«Слушайте,*** *- говорю я, - осталось всего полмесяца до начала занятий,* ***нельзя ли отложить встречу?»*** *- «Речь идет лишь о знакомстве, нам срочно, прекрасные условия…» (НКРЯ); -* ***А нельзя ли сделать для нас еще и серьги из этого жемчуга?*** *- Хорошо, я сделаю, - согласился ювелир, - но тогда вы немножко приплатите мне деньгами за серебряные замочки (НКРЯ);* - ***Координатор, нельзя ли на этот раз без меня?*** *Формулу Рапорта я знаю наизусть, - сказал Карпов. - Ты обязан присутствовать (Прошкин); - Тогава няма ли да е най-добре да минете направо на въпроса? - Да, направо на въпроса.(БНК); - Милорд, няма ли да е по-безопасно да оставим момчето тук на лодката? - По-безопасно, да. По-разумно – не (БНК); - Ами как ще го извадим, ако не го направиш? - Ама… ама - започна Пъзъл - няма ли да е по-добре ти да влезеш?(БНК).*

Приведенные примеры **свидетельствуют о том,** что в аналогичных коммуникативных ситуациях для болгарского языка **нехарактерно использование категории имперсональности**. Говорящий осуществляет мягкое побуждение, преимущественно прибегая к **личным формам глагола,** которые подчеркивают активную роль адресата в совершении действия.

Наиболее частое употребление безличных предложений в русском языке наблюдается в фатическом жанре прощания. При этом говорящий косвенно указывает на себя, используя данную конструкцию как тактический прием, направленный на то, чтобы непреднамеренно не оскорбить хозяев. В таких конструкциях нередко встречаются слова, усиливающие намерение совершить прощальное действие, например: *действительно*, *срочно*, *немедленно*, *к сожалению* и др.: - *Тонечка!* - ***Простите, Митя, но мне пора домой****. - Подождите же хоть пять минут! (Каверин); - Вот мы и расстаемся с вами, - печально сказала она. - Да… - тихо ответил Незнайка. -* ***Нам уже пора домой.*** *- Вы совсем недолго побыли у нас. -* ***Мне очень хочется побыть еще, но и домой хочется****, - опустив голову, сказал Незнайка (Носов); -* ***Ну что ж, мне пора,*** *- сказала я устало. - Да, я провожу тебя. Нынче ночью я была счастлива. На обратном пути немного поэзии. (Рудых); - А, тъкмо ми напомняш, че не мога да отсъствам дълго. Време е да тръгвам. - Жалко ... Поздравете всички от мен. (Енев); - Време е да тръгвам, че ще изпусна влака. Радвам се, че си поговорихме. - И на мен ми беше приятно. Отбивай се всякога когато имаш път насам (БНК); - Извинявам се на всички, но мисля, че е време да тръгвам. Утре рано имам разговор. - Не ми харесва това, че ще се върнеш сама на брега (БНК); - Заедно с това - прекъсна ме тя - ти кажи, че съм ти помагала да пишеш романа. - Не, по-добре това да си остане тайна. Офелия погледна часовника.* ***- Е добре, време ми е. До утре.*** *(БНК).*

В болгарском языке в ситуациях прощания наблюдается крайне редкое употребление имперсональных конструкций. Примером может служить конструкция *време ми е*, приведенная в последнем случае. В эксцерпированном корпусе большинство диалогических единиц реализуется с использованием личных форм глагола 1 лица единственного или множественного числа.

Для русского языка характерны бессубъектные конструкции, которые встречаются как в фатическом общении, так и в ситуациях, когда адресат намерен отказать инициатору диалога в удовлетворении просьбы, одновременно сохраняя теплые межличностные отношения: - *Евгений, дорогой, ненаглядный, возьмите меня к себе…Время няше уходит, мы уже не молоды, и* ***хоть бы в конце жизни нам не прятаться, не лгат.*** - ***Мне 55 лет, уже поздно менять свою жизнь*** *(Чехов).*

Безличные конструкции в русском языке встречаются в фатическом жанре комплимента, который относится к фатическим жанрам, способствующим улучшению межличностных отношений. В болгарском языке при выражении комплимента отсутствует использование безличных конструкций.

Комплимент оценивается обществом положительно и, как правило, воспринимается адресатом благосклонно. Он выполняет функцию повышения настроения, создания дополнительных стимулов к благожелательному отношению и коммуникации, что способствует достижению коммуникативных целей. Включение безличных конструкций в этот этикетный фатический жанр усиливает положительный эффект произнесенных реплик. При построении комплиментов различные языковые личности используют разные речевые стратегии, выбор которых определяется индивидуальными стилями говорящих: - *Мне стало жалко помешать вам, может быть, вы видели счастливый сон… - Ничего не видела! - Ну, все равно!* ***Но мне понравилась ваша улыбка****. Спокойная такая, добрая… большая! Людмила засмеялась, смех ее звучал негромко, бархатисто. - Я и задумалась о вас… (Горький); - Вы мыслите очень своеобразно, - сказала она, - вы оригинальный человек!* ***Мне понравились ваши замечания о Станиславском*** *(НКРЯ).*

Любой комплимент обусловлен желанием произвести положительное впечатление на собеседника, а для того чтобы вызвать у него положительные эмоции, необходимо учитывать его индивидуальные и личностные особенности. В связи с этим основными требованиями к комплименту выступают **соразмерность** – то есть адаптация высказывания к различным адресатам в зависимости от их возраста, степени знакомства с говорящим и других факторов – и **ситуативность,** проявляющаяся в выборе темы похвалы (внешность, интеллект, вкус и т. д.) в зависимости от конкретной коммуникативной ситуации. Кроме того, в соответствии с русским менталитетом, комплимент должен быть **искренним** и **нетривиальным** [7, с. 171].

В устной болгарской речи отмечается более частое использование безличных конструкций. Так, в фатическом жанре приветствия, особенно в ситуациях между хорошо знакомыми коммуникантами, говорящий часто задает вопрос ***„Как си?“,*** ожидая получения достоверной информации о состоянии собеседника. В отличие от формализованных ситуаций, где данный вопрос носит во многом стереотипный характер и предполагает стандартный ответ в рамках принятых в обществе вежливых формул (например, *Благодаря, добре*; *Добре съм, вие как сте* и др.), в неофициальных коммуникациях ответы нередко формулируются преимущественно с использованием безличных предложений: *Как да съм?* ***Спи ми се****; Днес* ***ми*** *е едно такова* ***заспало;*** *Много* ***ме мързи*** и др. под.

В болгарском языке безличные конструкции используются в диалогическом общении для выражения личного отношения говорящего к обсуждаемой теме: - *Виждаш ми се умърлушен, мой човек. Тая паплач май ти лази по нервите, а? - Направо* ***ми се драйфа*** *при вида на тия продупчени езици и обици по зърната на гърдите.; - По дяволите, постарай се никога повече да не изопачаваш истината в мое присъствие, защото от лъжите* ***ми призлява****!; - Потръпвам, когато чувам това,* ***прилошава ми*** *до дън душа, когато го слушам.; - Заповядвам ти да го отвориш! - Нарежданията ми… - Изобщо* ***не ми пука*** *какво ти е наредено!; - Доколкото знам, ти имаш много по-важна работа тук, в Опал. Той ме изгледа гадно. -* ***Не ми пука*** *особено какво мислиш по въпроса, Чудак.*

Сходство в использовании бессубъектных конструкций в русском и болгарском языках наблюдается в жанрах, ухудшающих межличностные отношения (например, в ссорах и упреках), при выражении оценки действий: - *Продай собаку, - говорит Бобров.* ***- Как тебе не стыдно!*** *- Ну тогда подари. Здесь ей будет лучше. - Ей-то - да. (Довлатов); - Лиза, сознайся, ты влюблена в Горизонтова! Верно?* ***- Как тебе не стыдно,*** *Татьяна, говорить о таких легкомысленных вещах в такой ответственный момент! - Я знаю-знаю, я все вижу! Вижу, как ты на него смотришь. Ты так на него смотришь из-за плеча, что у меня мурашки по спине пробегают (Аксенов); - Подлец! - развика се леля Емилия. - Ела бързо тук! Ела да ти опъна ухото!* ***Как не те е срам*** *да не ми се обадиш досега…(Вежинов); - Всичко сте обърнали с главата надолу! Ей сега ще извикам милиция! - Ние, без да искаме! - отвърнаха жално разбойниците. - Друг път няма! -* ***Как не те е срам,*** *момиченце! (БНК).*

По наблюдениям Б. Ю. Нормана, безличные конструкции в русском языке употребляются примерно в четыре раза чаще, чем во французском. В болгарском языке практически любой глагол может образовывать безличную форму с помощью возвратной морфемы **се** (например, *веднъж се живее*, *на вратата се почука*, *пита се* и *се отговаря*). Данная возвратно-безличная форма легко принимает разнообразные модальные оттенки, такие как выражение возможности или долженствования. Так, в предложении *По тревата не се ходи* запрет выражен с помощью безличной формы, что соответствует русскому выражению *По траве не ходить* с императивным инфинитивом [14].

Носитель болгарского языка, обладая такой стандартной грамматикализованной формой представления действия в отрыве от деятеля, использует её значительно чаще, чем носитель языка, в котором аналогичная грамматикализованная форма отсутствует. Это явление согласуется с одним из постулатов современного учения о грамматикализации, согласно которому автоматизация часто повторяющихся языковых последовательностей приводит к тому, что: «чем чаще какое-то значение приходит в голову говорящему и чем оно более коммуникативно востребовано, тем более регулярным, то есть „грамматичным“, становится его выражение. И наоборот: чем морфологичнее выражение грамматического значения, тем естественнее и привычнее его использование в речи». Следовательно, привычное использование набора «языковых техник» (их хабитуальность) оказывает существенное влияние на специфику соответствующей языковой картины мира. [14, с. 61–62].

Проведённое исследование демонстрирует, что безличные конструкции играют ключевую роль в фатическом дискурсе русского и болгарского языков, выполняя как коммуникативно-прагматические, так и культурно-когнитивные функции. Они обеспечивают возможность смягчения категоричности высказываний, скрытия активной позиции говорящего и реализации различных тактических стратегий, направленных на поддержание межличностного взаимодействия. Анализ показал, что безличные формы широко употребляются в жанрах фатического общения, таких как приветствия, прощания, побуждения и комплименты, а также в жанрах, потенциально ухудшающих межличностные отношения, включая конфликты и упрёки.

Сравнительный анализ русского и болгарского языков выявил значимую **несимметричность** использования безличных конструкций. В русском языке данные формы преимущественно служат для уменьшения категоричности высказываний и предотвращения вторжения в личное пространство адресата, что соответствует особенностям русского менталитета, ориентированного на фаталистическое восприятие мира и коллективистскую концептуализацию событий. В болгарском языке, напротив, безличные конструкции чаще акцентируют личную ответственность субъекта действия, а мягкое побуждение реализуется через личные формы глагола, что отражает национально-специфические коммуникативные сценарии и культурные нормы.

Таким образом, исследование подчёркивает ключевую роль безличных конструкций в реализации фатических жанров прощания и комплимента, указывая на их значимость для поддержания и регулирования межличностного общения. В русском языке они служат средством тактического смягчения коммуникативного воздействия и поддержания позитивного тона общения, в то время как в болгарской речевой практике подобные конструкции встречаются крайне редко и в основном реализуются через личные формы. Применение безличных форм в русской культуре также связано с концептуализацией неконтролируемых явлений и оценкой событий как неблагоприятных или небеспричинных.

Рассмотрение модальных, психологических и социальных безличных глаголов в болгарском языке (например, *трябва е*, *спи ми се*, *не ми е грижа*) выявило их роль в выражении пассивности, фатализма и отсутствия личной ответственности, а также в формировании национально-специфических паттернов восприятия действительности. Возвратная морфема ***се*** позволяет практически любому глаголу образовывать безличные формы, что способствует расширению функциональных возможностей языка и усилению выразительности коммуникации.

Безличные конструкции представляют собой сложное языковое явление, находящее отражение на пересечении синтаксиса, прагматики и культурной ментальности; их употребление определяется как структурными особенностями языковой системы, так и когнитивными и социальными факторами, формирующими картину мира носителей языков. Сравнительный анализ русского и болгарского языков показывает, что универсальная коммуникативная функция безличных форм сочетается с национально-специфическими стратегиями реализации фатического дискурса. В этом контексте безличные конструкции не только служат средством поддержания межличностной гармонии, но и отражают глубокие культурные и когнитивные особенности языкового сознания носителей.

Следовательно, исследование прагматики безличных конструкций в фатическом дискурсе позволяет глубже понять взаимосвязь языка, мышления и культуры, выявить закономерности национально-специфической концептуализации социальных и психологических реалий, а также определить направления дальнейших исследований в области сопоставительной лингвистики и когнитивной прагматики.

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PHILOSOPHICAL SCIENCES

ШАХИ ЯК ДЖЕРЕЛО МЕТАФОР ДЛЯ СОЦІАЛЬНО-ФІЛОСОФСЬКИХ РЕФЛЕКСІЙ

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CHESS AS A SOURCE OF METAPHORS FOR SOCIAL-PHILOSOPHICAL REFLECTIONS

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Анотація

Актуальність теми дослідження зумовлена поширенням практики використання метафор, пов'язаних із шахами, у філософських текстах. Мета дослідження – виявлення метафор, пов'язаних із шахами, як способу філософського осмислення соціальних стосунків, ситуацій, явищ та процесів. Методологія дослідження базується на методах аналізу та синтезу, порівняльному та тезаурусному методах. Аналіз результатів дослідження показує, що до метафор, породжених грою у шахи, часто вдаються для філософського осмислення стосунків, ситуацій, явищ та процесів, які відбуваються у суспільстві. Деякі з цих метафор навіть стають основою філософських концепцій для осмислення геополітичної картини світу (порівняння світу із шахівницею). Критика таких концепцій формує дискусію, яка розгортається в контексті соціальної філософії з рефлексіями щодо форм та сутності існування соціальної реальності, з виявленням діалектичних протиріч, притаманних соціуму в різних аспектах буття. Це дає підстави розглядати шахові метафори не лише як цікаві художні образи, що стилістично «прикрашають» філософські тексти, а ще й як джерело змістовних моделей, здатних формувати інший, альтернативний погляд на об'єкти осмислення – людину, як творця і актора культури, та суспільство у всіх проявах його функціонування з відповідними гуманістичними та ціннісними засадами.

Abstract

The relevance of the research topic is due to the widespread practice of using metaphors related to chess in philosophical texts. The purpose of the study is to identify metaphors associated with chess as a way of philosophically understanding social relationships, situations, phenomena, and processes. The research methodology is based on analysis and synthesis methods, comparative and thesaurus methods. Analysis of the research results shows that metaphors generated by the game of chess are often used to philosophically understand relationships, situations, phenomena, and processes that occur in society. Some of these metaphors even become the basis of philosophical concepts for understanding the geopolitical picture of the world (comparing the world to a chessboard). Criticism of such concepts shapes a discussion that unfolds in the context of social philosophy with reflections on the forms and essence of the existence of social reality, with the identification of dialectical contradictions inherent in society in various aspects of being. This gives grounds to consider chess metaphors not only as interesting artistic images that stylistically "decorate" philosophical texts, but also as a source of meaningful models capable of forming a different, alternative view of the objects of comprehension - man as a creator and actor of culture, and society in all manifestations of its functioning with the corresponding humanistic and value principles.

Ключові слова: людина, суспільство, культура, гра, цінності, геополітична картина світу, дискусія.

Keywords: person, society, culture, game, values, geopolitical picture of the world, discussion.

Вступ. Гра в шахи – одна з найдавніших ігор в історії людства, яка й по сьогодні не втрачає своєї актуальності ні як культурна практика, ні як джерело метафор.

Зважаючи на те, що метафори можуть бути цінним гносеологічним ресурсом [1; 2], завдяки якому можна виявити форми і розкрити сутність соціальної реальності [3], вивчення метафор, породжених грою у шахи, є актуальною науковою проблемою в контексті соціальної філософії.

Мета дослідження – виявлення метафор, пов'язаних із шахами, як способу філософського осмислення соціальних стосунків, ситуацій, явищ та процесів.

Методологія дослідження базується на методах аналізу та синтезу (для узагальнення теоретичного та емпіричного матеріалу), порівняльному методі (при співставленні особливостей гри у шахи в різних культурах), тезаурусному методі (для виявлення прямої і переносної смислової змістовності шахових термінів через семантичні зв'язки в контексті проблематики дослідження).

Результати дослідження. Метафори, породжені грою у шахи, – її правилами, гральними фігурами, атрибутикою та термінологією, – дозволяють описувати і осмислювати різні аспекти людського життя. І це логічно, адже сама гра в шахи з'явилася через спробу змоделювати різні ситуації, які виникають в конфліктах, насамперед, воєнних.

Народилася ця гра в Індії [4], де війна вважалася особистою справою правителя, його дхармою кшатрія, важливою лише для нього. Тому на шахівниці бачимо дві армії – одна проти одної, – кожну з яких очолює король зі своїм першим радником (ферзь, від іранського слова «фарзін») і повним набором військ – бойові слони, кіннота, піхота.

Потрапляючи в інший соціокультурний контекст, ця гра не змінює своїх правил (головна мета – загибель або полон ворожого короля – залишається незмінною), але набуває відповідних особливостей у назвах фігур. Наприклад, у французів бойова колісниця перетворюється на туру (*tour* – башта фортеці), а слона замінює офіцер. У німців та англійців слон перетворюється на єпископа (*Bischof*, *bishop*), і графічним символом цієї фігури стає єпископська митра, що не дивно, зважаючи на роль церкви у війнах середньовічної Європи.

Значно більших змін шахи зазнали в Китаї. «Полководця» (короля) супроводжують два радника замість одного (адже в давнину в китайській державі всі високі посади дублювалися), і всі вони не можуть виходити за межі «фортеці» – квадрата 3×3. Кількість пішаків, навпаки, зменшується, і вони не стоять цільним ланцюгом. А до колісниці додаються «гармати» або «катапульти» (*пао*). Слони тут теж є, але вони не можуть переходити «ріку» – лінію, що розділяє гральну дошку на дві половини.

Всі ці приклади вказують на те, що гра в шахи дозволяє моделювати не лише «театр воєнних дій», а й різноманітні географічні особливості та політичні конфігурації, що притаманні певним культурам.

Тому не дивно, що деякі з шахових фігур та позицій часто використовуються як метафори для характеристик людей, описання їх дій, та ситуацій, які виникають внаслідок цих дій.

Наприклад, найслабша з фігур, з найбільшими обмеженнями у пересуванні (може ходити лише на одне поле по вертикалі) – ***пішак*** – стала синонімом несамостійної людини, яка в своїх діях повністю залежить від волі інших.

Залежність пішаків від волі інших найбільш критично проявляється під час ***гамбіту*** – шахового дебюту, в якому гравець жертвує фігуру (найчастіше – пішака) заради швидкого розвитку ситуації або загострення гри: організації атаки, захоплення центру, тощо. Цей термін походить з італійської мови, де означає «підніжка». Звідси й переносне його значення – стратегічний трюк, продуманий хід або дія, яка здається жертвою (поступкою, ризиком), але насправді має на меті отримання переваги у довгостроковій перспективі. У шаховій партії це виглядає сміливо, зухвало, але в реальному житті викликає питання в морально-етичному плані: Хто і на якій підставі вирішує, кому бути «гравцями», а кому – «пішаками»? Ким і заради чого можна жертвувати?.. Особливої гостроти ці питання набувають в контексті соціально-політичних процесів, коли людей масово використовують як пішаків без їхньої на то згоди, всупереч їх волі. У ширшому плані ці питання виходять на філософську проблему співвідношення мети і засобів її досягнення.

Втім, не менш сміливо і зухвало виглядає й ***хід конем***. У шахах кінь – це єдина фігура, яка ходить незвичайно, «перестрибує» через інші фігури, що часто робить його ходи неочікуваними. Тому і в реальному житті, коли люди вдаються до неочікуваних дій, обхідного маневру або незвичного вчинку, це розцінюється, як «хід конем».

Головне, щоб хід конем не призвів до ***патової ситуації*** – положення, коли гравець, який має право ходу, не може це зробити, бо всі його фігури позбавлені можливості пересування, але при цьому його король не знаходиться під шахом, що веде до нічиєї. У реальному житті цим терміном означають безвихідний стан, коли жодна зі сторін не може досягти прогресу, а будь-який хід призводить до невигідних наслідків.

З безвихіддю пов'язаний ще один шаховий термін – ***цугцванг***, який означає ситуацію, коли у гравця, якому належить право ходу, немає жодного вигідного або нейтрального варіанту: будь-який хід веде до погіршення його ситуації і, як правило, до поразки, бо він змушений зробити хід. Цей термін походить з німецької мови, де буквально означає «примус до здійснення ходу» (*Zug* – хід, *Zwang* – примус). У метафоричному сенсі цей термін часто використовується не лише в бізнес-стратегіях, а й в соціальних стосунках, як характеристика одного із способів поведінкової маніпуляції.

Важкою, але не безвихідною, є ситуація, яка описується як ***цейтнот*** – брак часу для обдумування ходів, коли гра відбувається з контролем часу. У переносному значенні смисловий зміст цього терміну залишається незмінним – гостра нестача часу на виконання якоїсь справи, особливо – за наявності дедлайну.

Фінальні етапи шахової партії теж набули метафоричного значення в реальному світі. Про ***ендшпіль*** (заключна стадія партії, коли на дошці залишається мало фігур) згадують у воєнних конфліктах після розгрому основних сил супротивника, коли сторони переходять до фінальної боротьби за перемогу або перемир'я. А ***шах і мат*** (ситуація, коли король супротивника атакований і не має жодного можливого ходу для захисту, у перекладі з перської «шах мат» – «володар безсилий» або «володар мертвий») – констатація перемоги, кінець гри.

Але найбільш масштабною, так би мовити, глобальною метафорою є порівняння світу із ***шахівницею***. Ця метафора набуває поширення не лише в творах художньої літератури, аналіз яких розгортається в контексті діхотомій «реальне життя – світ шахів» [5] та «людина, що грає у шахи, – бог, деміург» [6], а й в політичній публіцистиці, де ці діхотомії поєднуються у геополітичній картині світу. Прикладом є відомий твір Збігнєва Бжезинського

«Велика шахівниця. Американська першість та її геостратегічні імперативи» [7].

До цієї метафори звертаються й кінематографісти, коли вдаються до філософських роздумів про людину, про морально-етичні засади соціального життя.

В цьому плані привертає увагу епізод серіалу «В полі зору» (*Person of Interest*, 2011-2016), коли один із головних героїв – Гарольд Фінч, розробник штучного інтелекту – навчає свою Машину грі у шахи.

– Це корисна вправа для розуму, – каже Фінч, переставляючи фігури на шахівниці. – Упродовж століть великі мислителі були заворожені цією грою. Але особисто мені не подобається грати. Знаєш чому?

– Ні, – надсилає Машина свою відповідь на екран мобільного телефона Фінча.

– Тому, що ця гра народилася в жорстокі часи, коли людське життя мало цінувалося. Тоді вірили, що деякі люди цінуються більше за інших. Королі, пішаки… Я не думаю, що чиєсь життя може цінуватися більше іншого… Запам'ятай: шахи – це просто гра. Справжні люди – це не фігури. І ти не можеш цінувати одних більше за інших. Людьми неможна жертвувати, як фігурами. Урок в тому, що той, хто бачить світ як шахову дошку, гідний програти.

Зважаючи на те, що Фінч готував Машину до надскладної роботи з виявлення злочинів, які потенційно могли скоїти люди, з визначення, хто в цих ситуаціях є потенційною жертвою, а хто – злочинцем, можна прийняти його монолог як настанову, в якій бажане переважає дійсне. Зрозуміло, що йому хочеться вірити в те, що «жорстокі часи» залишилися у далекому милому. І зрозуміло, що на перших етапах навчання Машина ще не здатна вступати із своїм творцем в дискусію, ставлячи запитання: Хіба в наш час людське життя цінується більше, ніж у минулі часи? Так, ця думка декларується, транслюється, та хіба насправді реалізується? І хіба можна розв'язання цієї проблеми покладати на штучний інтелект? Це що – визнання неспроможності людей встановити справжню соціальну рівність, чи бажання перекласти відповідальність за це на когось іншого?

Хай там як, а подібні питання постають не лише в межах кінокритики, але й у більш широкому дискурсі соціальної філософії в поєднанні з відповідною тематикою аксіології, футурології та інших філософських напрямів та концепцій.

Висновки. Дослідницька розвідка показала, що до метафор, породжених грою у шахи, часто вдаються для філософського осмислення стосунків, ситуацій, явищ та процесів, які відбуваються у суспільстві. Деякі з цих метафор навіть стають основою філософських концепцій для осмислення геополітичної картини світу, як, наприклад, порівняння світу із шахівницею. Критика таких концепцій формує дискусію, яка розгортається в контексті соціальної філософії з рефлексіями щодо форм та сутності існування соціальної реальності, з виявленням діалектичних протиріч, притаманних соціуму в різних аспектах буття.

Це дає підстави розглядати шахові метафори не лише як цікаві художні образи, що стилістично «прикрашають» філософськи тексти, а ще й як джерело змістовних моделей, здатних формувати інший, альтернативний погляд на об'єкти осмислення – людину, як творця і актора культури, та суспільство у всіх проявах його функціонування з відповідними гуманістичними та ціннісними засадами.

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PHYSICS AND MATHEMATICS

THE USE OF ARTIFICIAL INTELLIGENCE IN MATHEMATICS

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Abstract

Artificial intelligence (AI) has emerged as a strategic and transformative technology that profoundly influences both theoretical and applied studies in the field of mathematics. While traditional mathematical approaches often rely on human intuition, experience, and intensive computational processes, AI-based methods enable the automation of these processes, providing faster, more systematic, and highly accurate solutions. In particular, advanced algorithms such as machine learning, deep learning, and artificial neural networks are effectively employed in the identification of mathematical patterns within large and complex datasets and in solving multidimensional problems.

The application areas of artificial intelligence in mathematics encompass a wide range of domains, including symbolic computation, optimization, numerical analysis, mathematical modeling, and systems that support theorem proving. These systems not only generate solutions to existing problems but also contribute to the discovery of new mathematical relationships and the development of hypotheses. This enhances the significance of human–machine collaboration in mathematical research and allows mathematicians to concentrate on higher-level abstraction and theoretical exploration.

In the context of education, artificial intelligence facilitates the creation of personalized learning environments in mathematics instruction. Intelligent tutoring systems analyze students' knowledge levels, learning speeds, and error patterns to deliver adaptive content, thereby increasing the effectiveness of the learning process. AI-supported applications promote deeper conceptual understanding of mathematical concepts while also providing valuable data to educators for assessment and evaluation purposes.

Nevertheless, the use of artificial intelligence in mathematics entails certain limitations and ethical considerations. AI systems cannot fully replace human intuition, creative thinking, and abstract reasoning. Furthermore, issues related to data quality, algorithmic bias, and system reliability require careful attention. This study aims to comprehensively examine the role of artificial intelligence in mathematics and to evaluate its opportunities and challenges from an academic perspective.

Keywords: Artificial intelligence, Mathematics, Machine learning, Deep learning, Symbolic computation, Mathematics education, Optimization.

Artificial intelligence (AI) has brought significant transformation to the field of mathematics, as it has in many other scientific disciplines. While traditional mathematical problem-solving methods often rely on human intuition and lengthy calculation processes, artificial intelligence accelerates these processes and makes them more efficient. Especially in big data analysis, modeling, and solving complex problems, AI-supported systems have introduced a new dimension to mathematical studies.

One of the most common applications of artificial intelligence in mathematics is problem solving. Machine learning and deep learning algorithms can learn from past data and propose solutions to new mathematical problems. For example, symbolic computation systems are capable of solving complex equations, making predictions about theorems, and even discovering new mathematical relationships. This allows mathematicians to focus more on creative and theoretical aspects of their work.

In the field of education, artificial intelligence has also significantly influenced mathematics teaching. Intelligent tutoring systems provide personalized learning experiences by adapting content to students' learning speed and level. AI-based applications analyze students' mistakes and offer immediate feedback, making the learning process more effective. As a result, students' interest in mathematics increases, and abstract concepts become easier to understand.

However, the use of artificial intelligence in mathematics also has certain limitations and ethical considerations. AI systems cannot completely replace human thinking; human intuition, abstract reasoning, and creative problem generation remain essential. Additionally, the accuracy and reliability of AI systems depend heavily on the quality of the data used to train them.

In conclusion, artificial intelligence stands out as a powerful supportive tool in the field of mathematics. When used correctly and responsibly, it accelerates mathematical research, enhances educational effectiveness, and paves the way for new discoveries. In the future, the interaction between artificial intelligence and mathematics is expected to grow further, leading to innovative applications in this field.

1. Introduction

The rapid evolution of artificial intelligence (AI) has fundamentally transformed contemporary scientific inquiry, reshaping not only applied disciplines but also foundational fields such as mathematics. Historically, mathematics has been regarded as a domain driven primarily by human abstraction, deductive reasoning, and creative insight. Mathematical progress has tradition-

ally depended on rigorous proof, symbolic manipulation, and the intellectual intuition of mathematicians. However, the growing complexity of modern mathematical problems—particularly those involving high-dimensional spaces, nonlinear systems, large-scale datasets, and computational intractability—has necessitated the incorporation of advanced computational methodologies. (Gowers & Roughgarden, 2022).

Artificial intelligence has emerged as a critical tool that complements and extends traditional mathematical approaches. Unlike conventional computational methods, AI systems are capable of learning from data, identifying hidden patterns, and adapting to new problem structures without explicit programming. Techniques such as machine learning, deep learning, and symbolic reasoning have enabled the automation of complex analytical processes, significantly accelerating mathematical computation and exploration. As a result, AI not only enhances efficiency but also introduces new epistemological questions regarding the nature of mathematical knowledge and discovery. (Bengio et al., 2021).

In mathematical research, artificial intelligence has proven particularly valuable in areas such as optimization, numerical analysis, mathematical modeling, and theorem proving. AI-driven systems can process vast quantities of data and explore solution spaces that exceed human cognitive limits. These capabilities have facilitated the discovery of novel mathematical relationships and have contributed to the validation of complex proofs. Consequently, mathematics is increasingly characterized by a collaborative paradigm in which human reasoning and machine intelligence operate in tandem.

Beyond research, artificial intelligence has profoundly influenced mathematics education. Intelligent tutoring systems and adaptive learning platforms have enabled personalized instructional environments that respond dynamically to individual learners' needs. By analyzing students' performance, learning pace, and error patterns, AI-based systems provide targeted feedback and customized learning pathways. This shift toward personalized education has significant implications for student engagement, equity, and conceptual understanding in mathematics.

Despite these advancements, the integration of artificial intelligence into mathematics raises critical methodological, ethical, and philosophical concerns. Issues such as algorithmic transparency, data bias, and the interpretability of AI-generated outcomes challenge the foundational principles of mathematical rigor and clarity. Therefore, a systematic academic examination of artificial intelligence in mathematics is essential to understand its potential, limitations, and long-term implications. This study aims to contribute to this discourse by providing a comprehensive analysis of AI applications in mathematics from both research and educational perspectives.

2. Literature Review

The relationship between artificial intelligence and mathematics has been the subject of extensive scholarly investigation over the past several decades. Early research in this area focused primarily on symbolic computation and rule-based expert systems designed to replicate human reasoning in algebraic manipulation and logical inference. These systems laid the groundwork for automated reasoning and demonstrated the feasibility of machine-assisted mathematical problem solving. (Buchberger, 2006).

With the advent of machine learning and increased computational power, the focus of research expanded toward data-driven approaches. Studies in numerical analysis and optimization have shown that machine learning algorithms, particularly neural networks, can approximate complex mathematical functions with remarkable accuracy. These findings have positioned AI as a viable alternative or complement to traditional numerical methods, especially in contexts involving uncertainty, noise, or incomplete information.

Recent literature highlights the growing role of deep learning in mathematical modeling and pattern recognition. Researchers have explored the application of deep neural networks in solving differential equations, optimizing high-dimensional systems, and identifying structures within large mathematical datasets. Additionally, AI-assisted theorem proving has emerged as a promising area of study. Automated proof assistants and hybrid human–AI systems have demonstrated success in verifying complex proofs and suggesting potential proof strategies, thereby enhancing mathematical rigor and efficiency.

In the domain of mathematics education, a substantial body of literature examines the effectiveness of AI-based instructional tools. Empirical studies report that intelligent tutoring systems improve students' problem-solving abilities, conceptual understanding, and motivation. Adaptive assessment systems provide continuous feedback and enable formative evaluation, supporting more responsive and data-informed teaching practices. However, scholars also caution against excessive reliance on automated tools, emphasizing the importance of maintaining human guidance and critical thinking in mathematical learning. (Baker & Inventado, 2014).

Ethical and philosophical discussions constitute another significant dimension of the literature. Researchers have raised concerns regarding the opacity of AI models, the reproducibility of AI-generated results, and the potential erosion of fundamental mathematical skills. The question of whether AI can truly "understand" mathematics or merely simulate mathematical reasoning remains a topic of ongoing debate.

Overall, the literature suggests that artificial intelligence has become an indispensable component of modern mathematical practice. Nevertheless, it also underscores the need for interdisciplinary research that integrates mathematical rigor, computational innovation, and ethical responsibility. Building on these insights, the present study seeks to synthesize existing research and offer a comprehensive evaluation of artificial intelligence in mathematics.

3. Methodology

This study employs a comprehensive qualitative research methodology grounded in systematic literature analysis to investigate the applications and implications of artificial intelligence in mathematics. Given the con-

ceptual and interdisciplinary nature of the topic, a qualitative approach was deemed most appropriate to explore theoretical frameworks, emerging trends, and methodological developments within the existing body of knowledge. Rather than conducting empirical experiments, the study focuses on synthesizing and critically evaluating scholarly research to provide a holistic understanding of AI integration in mathematical research and education.

The data sources for this study consist of peer-reviewed journal articles, conference proceedings, academic monographs, and authoritative reports published in internationally recognized databases. Priority was given to recent publications addressing artificial intelligence techniques such as machine learning, deep learning, symbolic computation, automated theorem proving, and intelligent tutoring systems within mathematical contexts. Classical foundational works were also included to ensure theoretical continuity and historical depth.

The literature selection process followed a structured review protocol. Initially, relevant studies were identified through keyword-based searches. Subsequently, inclusion and exclusion criteria were applied to ensure academic rigor, relevance, and methodological validity. Selected studies were then subjected to thematic content analysis, allowing for the identification of recurring concepts, methodological patterns, and theoretical contributions. This process facilitated the categorization of AI applications in mathematics into two primary domains: mathematical research and mathematics education.

Within the domain of mathematical research, the analysis focused on areas such as optimization, numerical analysis, symbolic reasoning, mathematical modeling, and theorem proving. In the educational domain, emphasis was placed on adaptive learning systems, personalized instruction, assessment technologies, and learner analytics. These categories provided a structured framework for examining how artificial intelligence reshapes mathematical practices across different contexts.

In addition to technical applications, the methodology incorporates an analytical examination of ethical and epistemological considerations. Issues related to algorithmic transparency, data dependency, bias, and the epistemic status of machine-generated mathematical knowledge were critically assessed. By integrating methodological rigor with philosophical reflection, this study aims to present a balanced and academically grounded perspective on the role of artificial intelligence in mathematics.

4. Discussion

The analysis reveals that artificial intelligence has significantly expanded the methodological and conceptual boundaries of mathematics. In mathematical research, AI-driven approaches enable the efficient handling of problems characterized by high complexity, nonlinearity, and large-dimensional spaces. Machine learning models, particularly neural networks, have demonstrated remarkable success in approximation theory, pattern recognition, and optimization, offering alternative solutions to classical analytical methods.

One of the most profound contributions of artificial intelligence lies in its capacity to support mathematical discovery. AI systems are capable of analyzing vast datasets and identifying latent structures that may elude traditional analytical techniques. In recent studies, AI-assisted tools have been used to generate conjectures, suggest proof strategies, and verify logical consistency within complex mathematical arguments. This indicates a paradigm shift from purely human-driven discovery toward collaborative human–machine intelligence.

In the realm of automated theorem proving, artificial intelligence has shown considerable promise. While traditional proof construction relies heavily on human intuition and expertise, AI-based proof assistants can systematically explore large logical spaces, reducing cognitive load and minimizing error. However, the interpretability of machine-generated proofs remains a critical concern, particularly in disciplines where transparency and formal justification are essential.

From an educational perspective, the discussion highlights the transformative impact of artificial intelligence on mathematics instruction. Adaptive learning platforms and intelligent tutoring systems provide individualized learning pathways that respond dynamically to students' performance and cognitive profiles. Empirical findings suggest that such systems enhance conceptual understanding, reduce anxiety toward mathematics, and promote learner autonomy. Furthermore, AI-driven assessment tools enable continuous formative evaluation, offering timely feedback to both learners and educators.

Despite these advantages, several challenges emerge. The reliance on large datasets raises concerns regarding data quality, representativeness, and bias. Additionally, the opacity of certain AI models contradicts the mathematical emphasis on explainability and logical clarity. There is also a risk that excessive dependence on automated systems may weaken foundational mathematical skills if not complemented by traditional pedagogical approaches.

Ethical considerations further complicate the integration of artificial intelligence in mathematics. Issues of accessibility, equity, and algorithmic fairness must be addressed to prevent the amplification of existing educational and research disparities. Therefore, while artificial intelligence offers substantial benefits, its implementation requires critical oversight and interdisciplinary collaboration.

5. Conclusion

This study demonstrates that artificial intelligence has become an integral and transformative force within the field of mathematics, influencing both research methodologies and educational practices. Through advanced computational capabilities, AI enhances problem-solving efficiency, supports theoretical exploration, and facilitates the analysis of complex mathematical systems. Its applications extend beyond automation, contributing to knowledge generation and conceptual innovation.

However, artificial intelligence should not be perceived as a replacement for human mathematical rea-

soning. Core elements such as intuition, creativity, abstraction, and critical judgment remain uniquely human and indispensable to mathematical progress. The most effective applications of AI arise from a collaborative model in which human expertise and machine intelligence complement one another.

The findings also emphasize the necessity of addressing methodological and ethical challenges associated with AI use in mathematics. Ensuring transparency, explainability, and data integrity is essential to maintaining the epistemological foundations of the discipline. In educational contexts, AI-based tools must be integrated thoughtfully to support learning without undermining fundamental cognitive development.

Future research should prioritize the development of explainable artificial intelligence models aligned with mathematical reasoning processes. Longitudinal empirical studies are also needed to assess the sustained impact of AI-driven tools on mathematical understanding and research productivity. As artificial intelligence continues to evolve, its interaction with mathematics is expected to deepen, offering new opportunities for discovery, innovation, and educational excellence.

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POLITICAL SCIENCES

A NEW STAGE OF RELATIONS BETWEEN THE REPUBLIC OF AZERBAIJAN AND HUNGARY: STRATEGIC PARTNERSHIP AND TURKIC WORLD

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Abstract
Azerbaijan and Hungary, possessing unique geopolitical and economic positions, over the past decades have managed to turn their relations into a strategic partnership, which covers such key areas as politics, economics, energy, culture and the humanitarian sphere. In the face of global challenges, as energy security and new forms of economic interaction come to the fore, relations between the two countries take on a new dimension. Over the past years, Azerbaijan and Hungary have shown an example of a dynamic and constructive dialogue at the highest level. Notable is the fact that Hungary is an observer in the Organization of Turkic States. Since the beginning of the 2020s, several key visits of Azerbaijani President Ilham Aliyev to Hungary and Hungarian Prime Minister Viktor Orban to Azerbaijan have taken place, which have played an important role in strengthening political ties.
Keywords: Azerbaijan, Hungary, Trans-Adriatic Gas Corridor [TAP], Organization of Turkic States.

Introduction

In the modern system of international relations, the deepening of interstate cooperation is determined not only by geographical proximity and economic interests, but also by common values, historical ties and mutually beneficial strategic cooperation. In the context of a changing international order, Azerbaijan's foreign policy priorities necessitate strong cooperation with both global players and regional centers of power. Independent Azerbaijan develops mutually beneficial relations with neighboring and distant states in various fields, both bilaterally and multilaterally. In this sense, the relations that have developed between Azerbaijan and Hungary are exemplary. The development of bilateral and multilateral cooperation with Hungary, a strategic partner of Azerbaijan and one of the most reliable partners in the European Union, is one of the main directions of our country's foreign policy. Taking similar positions both in the region and on international platforms, our states over time not only strengthened friendly relations, but also formed a multifaceted model of cooperation based on strategic partnership.

In this sense, the relations that have developed between Azerbaijan and Hungary are exemplary. It should be noted that diplomatic relations between the two countries were established in 1992. In 2004, the Embassy of Azerbaijan was opened in Hungary, and in 2009 - the Embassy of Hungary in our country. Interparliamentary ties between our friendly countries are also developing at a high level. A working group on Azerbaijani-Hungarian inter-parliamentary relations operates in Parliament (Milli Majlis). Dozens of documents signed so far between the two countries play an important role in strengthening the legal framework. The Joint Strategic Partnership Declaration, signed in 2014, is essential to the development of our relationship. Azerbaijani-Hungarian cooperation was further strengthened with the signing of the Joint Declaration on Expanded Strategic Partnership in 2023.

Relationship Root: A Values-Based Partnership

Although Azerbaijani-Hungarian relations were established in 1992, their strategic nature has become noticeable in the last decade. The Joint Declaration on Strategic Partnership, signed in 2014, and its expanded version in 2023 became not just a diplomatic act, but a conceptual framework expressing the mutual interests and long-term intentions of the two states. The range of cooperation - from energy security to education and the humanitarian sphere - demonstrates the depth of this partnership. Regular mutual visits and meetings of heads of state played an indispensable role in bringing these relations to a high level.

The parties make a unique contribution to geopolitical relations, based on the principles of sovereignty, equality and non-interference in internal affairs, as well as supporting each other within the framework of international organizations. The fact that Hungary is one of the countries supporting Azerbaijan's interests in the European Union creates important diplomatic support for our republic's efforts to integrate into Europe.

On February 18, 2008, the Joint Statement of the President of the Republic of Azerbaijan and the President of Hungary was signed, which emphasized support for the fundamental principles and norms of the Charter of the United Nations, the Helsinki Final Act and the principles of international law, such as sovereignty, territorial integrity and inviolability of state borders. The parties announced their entry into a strategic partnership in order to strengthen relations by deepening and expanding cooperation between the two countries in areas of mutual interest, both bilaterally and multilaterally. The Joint Statement indicated:

- creation of a Strategic Dialogue to discuss bilateral relations, as well as global and regional issues of mutual interest;

- enhanced cooperation in the United Nations, including its specialized agencies and institutions, OSCE, Council of Europe, as well as on issues related to the EU, NATO and other international and regional forums, etc. [2]

In November 2014, the Joint Declaration "On Strategic Partnership between the Republic of Azerbaijan and the Republic of Hungary" was signed, which also pointed to joint initiatives on important regional

and international issues, of common interest, to promote links between foreign policy think tanks and research institutes with a view to enhancing exchanges and facilitating their cooperation, intensifying their efforts to peacefully resolve conflicts in the world and strengthen international peace and security. " [1]

Signed in Budapest in 2023, the Declaration on Strategic Partnership further strengthened the legal and political framework for this relationship. In a press statement during his working visit to Hungary, President of the Republic of Azerbaijan Ilham Aliyev praised the relations between the two countries, saying that Azerbaijan and Hungary are friendly countries, strategic partners, and stressed that relations are further strengthened, while recalling that relations between Baku and Budapest are based on historical traditions and unshakable friendship: "Once again, we saw that our positions on many issues coincide. Signed in Budapest in 2023 When we look at the processes taking place today in a changing world, there is no big difference in our positions. One of the similarities is that Hungary is landlocked. Azerbaijan is also one of these countries. Yes, we are located on the coast of the Caspian Sea, but we also have no access to the open seas." [5]

Joint participation in such global events as COP29, cooperation in the field of energy, transport, culture, defense and law, outlines the contours of a new geopolitical model.

Inter-parliamentary ties between the two countries are also developing successfully. Mutual visits of members of the Azerbaijan-Hungary Working Group on Inter-Parliamentary Relations and the Hungarian-Azerbaijan Inter-Parliamentary Friendship Group are regular. Close cooperation is maintained within the framework of international parliamentary organizations [8].

Energy - geopolitical bridge and strategic pillar

Energy cooperation with Hungary confirms Azerbaijan's growing role in the European energy market. The energy cooperation relations formed between Azerbaijan and Hungary are currently reaching a strategic level. As President Ilham Aliyev noted, Hungarian companies participate in the main oil and gas projects of Azerbaijan - Azeri-Chirag-Guneshli and Shahdeniz. [6] This is not only an economic interest, but also an indicator of a long-term partnership based on mutual trust. The resource base of Azerbaijani gas is quite extensive and expanding, new gas fields will be commissioned. Today Azerbaijan exports natural gas to 12 countries. 10 of them are European countries, and 8 are members of the European Union [7]. The European Commission recognizes Azerbaijan as a pan-European gas supplier and a reliable partner. The commissioning of new gas fields, the expansion of the geography of natural gas exports and the status of a pan-European supplier further strengthen the role of Azerbaijan in the field of energy security. In particular, the planned projects in the field of green energy - 6 thousand megawatts of production capacity - serve both to optimize domestic resources and contribute to the process of green transition in Europe. The next contract is supposed to be signed in 2026. The Hungarian company will start working on the onshore oil fields of Azerbaijan. The operation of Azerbaijani natural gas to Hungary has been carried out since 2024. It was decided to organize gas supplies at the level of Hungary's needs. Azerbaijan is also actively working with Hungary in the field of green energy. It is planned to produce 6 thousand megawatts of green energy over the next five years, while 500 megawatts have been created over the past two years. Thus, only these projects will save about 3-4 billion cubic meters of gas [7].

Energy infrastructure stretching from the Caspian Sea through the Black Sea to Europe is not just a technological project, it is the result of trust, mutual confidence and political will between regions. Azerbaijan's energy exports are no longer limited to oil and gas, but also accelerate the transition to green energy. The agreement on strategic partnership in the field of green energy, signed in Bucharest by the governments of Azerbaijan, Hungary, Romania and Georgia, provides for the transfer of energy between our countries and the implementation of new energy projects. This initiative will also bring the huge wind power potential of the Caspian Sea to European markets and will further diversify Europe's energy security. These projects, in particular, the construction of an underwater power transmission line across the Black Sea, will increase the volume of energy transportation between Europe and Azerbaijan and will contribute to the use of renewable energy sources. We are also actively working with Hungary in the field of green energy. Azerbaijan has a very large-scale program in the field of green energy. Over the next five years, we will produce 6,000 megawatts of green energy. Over the past two years, 500 megawatts have been created, 6 thousand megawatts will be delivered within five years. Thus, only these projects will allow us to save about 3-4 billion cubic meters of gas, the main direction of supply, of course, will be Turkey and European countries. Cooperation in the energy sector is of particular importance. MOL Group owns a 9.57% stake in the Azeri-Chirag-Guneshli field and an 8.9% stake in the Baku-Tbilisi-Ceyhan pipeline project. The memorandum of understanding on cooperation in the field of natural gas between the Ministry of Economy of the Republic of Azerbaijan and the Ministry of Foreign Affairs and Trade of Hungary, signed in Budapest on January 30, 2023, laid the foundation for further success in this direction [5]. On June 2, 2023, an agreement was signed between the State Oil Company of the Republic of Azerbaijan (SOCAR) and the MVM group of companies on the sale of 100 million cubic meters of natural gas. On June 5, 2024, documents were signed with the MVM group of companies on the acquisition of a stake in the Shahdeniz project, and on September 20, documents on exploration, development and production at the Shamakha-Gobustan field were signed with the MOL group of companies.

As part of the Solidarity Ring initiative, on April 25, 2023, a memorandum of understanding was signed in Sofia between Bulgartransgaz (Bulgaria), Transgaz (Romania), FGSZ (Hungary), Eustream (Slovakia) and SOCAR.

The Government of Hungary supports the establishment of a green energy corridor based on the "Strategic Partnership Agreement for the Development and

Transfer of Green Energy between the Governments of the Republic of Azerbaijan, Georgia, Romania and Hungary."

Ally of economic growth: mutual investment and trade

The growth of trade and investment initiatives between the two countries indicates that cooperation is carried out not only at the state, but also at the business level. Projects implemented by Hungarian companies in the liberated territories of Azerbaijan, the construction of infrastructure facilities and educational institutions, are also a new stage in post-conflict diplomacy. This indicates that Hungary has been supporting the territorial integrity and sovereignty of Azerbaijan since the establishment of diplomatic relations and during the 44th day war. Trade relations in bilateral relations also demonstrate quite positive dynamics. Economic commissions operate between the two countries, business forums are held. Hungarian companies show great interest in the agricultural, industrial, pharmaceutical and construction sectors of Azerbaijan. At the same time, Hungary can be seen as an entry into the Central European market for Azerbaijani products.

Agreements signed between SOCAR and MVM, MOL and other major Hungarian companies indicate the creation of a real economic model in the energy and industrial sectors. In addition, cooperation in the field of pharmaceutical production, space technologies and the creation of free economic zones is the beginning of the use of the technological potential of a friendly country in Azerbaijan [4].

Economic cooperation between Azerbaijan and Hungary has been developing rapidly in recent years. Both countries cooperate mutually beneficial, especially in the fields of energy, agriculture, transport and services. Azerbaijan, which has natural resources, modern transport infrastructure and a strategic geographical position, puts forward proposals in various fields that meet the economic interests of Hungary.

Economic relations, strategic partnership and friendship between the two countries are based on mutual respect and trust. As of the end of 2024, trade between our countries increased by 29 percent, which is a significant indicator of the strengthening and development of relations. This growth is due to the expansion of Azerbaijan's presence in European markets and the expansion of trade relations with Hungary.

In addition, the volume of foreign direct investment from Hungary to the Azerbaijani economy in 2024 amounted to 1.018 billion US dollars. This indicates Hungary's interest in the economy of Azerbaijan and the development of mutual investment relations between the two countries. Azerbaijani investors, in turn, invest heavily in agriculture, transport and other sectors of Hungary, which further strengthens the economic partnership [3].

This investment in the Hungarian economy is important not only in terms of financial resources, but also in terms of technological development and innovation in various fields. Such cooperation not only ensures economic growth, but also allows deepening strategic relations between countries and implementing new projects on a mutually beneficial basis.

Hungarian companies are interested in participating in the restoration and construction work carried out in the liberated territories. The KÉSZ group of companies is reconstructing the village of Soltanly, Jebrail district. At the expense of the Hungarian government, buildings for preschool and general education institutions will be built in the village of Soltanly. Hungarian companies traditionally participate in the Azerbaijan international exhibitions "Reconstruction, Restoration and Development of Karabakh" - "Rebuild Governance" held in Baku.

Meetings of the Joint Commission on Economic Cooperation between the Governments of Azerbaijan and Hungary are held annually. Joint business forums are regularly organized in the capitals of both countries. The last, 11th meeting of the Joint Commission was held in Budapest in June 2025.

Important steps have been taken to develop cooperation in the industrial sphere. On July 10, 2023, a joint venture agreement was signed between Azerbaijan Investment Company OJSC and the Hungarian company Hell Energy, and on July 31, an agreement on the joint production of pharmaceuticals in Azerbaijan between Scandens Pharmaceutical Industries Ltd LLC and Gedeon Richter. On April 24, 2025, a Memorandum of Understanding was signed between Azerkosmos and 4iG Space and Defense Ltd. Also in January 2022, a Memorandum of Understanding was signed between the Alyat Free Economic Zone and the Hungarian Export Promotion Agency [6].

There are also ample opportunities for developing cooperation in the field of agriculture. In 2023 and 2024, mutual visits of the Ministers of Agriculture of Azerbaijan and Hungary took place.

The development of bilateral relations in the field of military and defense industry is of mutual interest. In 2023 and 2024, mutual visits of the defense ministers of Azerbaijan and Hungary took place. Hungary was represented by the national pavilion at the 5th Azerbaijan International Defense Exhibition "ADEX-2024" and the 14th International Exhibition of Internal Security, Protection and Rescue Means "Securex Caspian," held in Baku on September 24-26, 2024.

Education and humanitarian relations: the basis of the future

Azerbaijani-Hungarian relations are strengthened not only by political and economic, but also by historical and cultural ties. The creation by Hungary of educational opportunities for hundreds of Azerbaijani students within the framework of the Stipendium Hungaricum program, the installation of a bust of Nizami Ganjavi in Hungary, the opening of cultural centers at the Azerbaijan University of Languages show that cooperation is strategic and at the cultural and humanitarian level.

The Embassy of Azerbaijan in Hungary translates, publishes and distributes books on the history, literature and culture of our country into Hungarian. Concerts are organized with the participation of famous musicians. Cooperation is also developing in the field of education; relations between universities of the two countries have been established, joint projects are being implemented. These are sincere steps aimed at deepening the

integration and rapprochement of peoples. Such an atmosphere is the basis of both cultural diplomacy and long-term mutual respect.

In connection with the announcement of Shushi as the "Cultural Capital of the Turkic World," and Veszprem as the "Cultural Capital of Europe" for 2023, on January 30 of the same year, a "Memorandum of Understanding was signed to establish friendly relations and cooperation in the field of culture, tourism, urban planning, science, economy and other spheres of public life between Shusha, Republic of Azerbaijan, and Veszprem, Republic of Hungary."

The level of humanitarian cooperation between the two countries is currently satisfactory. Hungarian students are also allocated educational scholarships under the Intergovernmental Scholarship Program. Currently, up to 700 Azerbaijani students study in Hungary.

On October 19, 2023, the opening of the bust of the great Azerbaijani poet and thinker Nizami Ganjavi took place in the Hungarikum park in Lakitelek (Hungary).

The Hungarian Language and Culture Center operates at the Azerbaijan University of Languages. On May 19, 2025, the Center for Azerbaijani Language and Culture was opened at the Lorand Eötvös University (ELTE), one of the leading universities in Hungary [5].

Direct scheduled flights operated by Wizz Air between the two capitals contribute to the expansion of tourist links.

Bridge between the Turkic world and Europe

The activities of the Representative Office of the Organization of Turkic-Speaking States in Budapest and the observer status of Hungary in this organization are also of particular importance from the point of view of cultural and political cooperation. Prime Minister Viktor Orban and Minister of Foreign Affairs and Foreign Trade Peter Siyarto have repeatedly stated that Hungary is both the easternmost state in Europe and the westernmost state in the Turkic world.

In July 2024, Viktor Orban visited Shusha to participate in the informal Summit of Heads of State of the Organization of Turkic States. The adopted Karabakh Declaration noted the valuable contribution of Hungary to the work of the OTG as an observer.

On May 21, 2025, an informal Summit of the Heads of State of the Organization of Turkic States was held in the Hungarian capital Budapest, where it was noted that Hungary intends to play the role of a bridge between Europe and the Turkic world, and Azerbaijan is an important player at the origins of this bridge. At this Summit, President Ilham Aliyev stated that "This is our family" and the inclusion of a non-Turkish state such as Hungary in the ranks of this family strengthens the inclusive strength of the organization and its potential for influence [1]..

Conclusion

The "Law on the Protection of Sovereignty," adopted by Hungary in 2023, reflects the spirit of resistance to foreign interference in the country's political system. It is noteworthy that the philosophy of this law also coincides with the policy pursued in Azerbaijan aimed at independent decision-making and maintaining internal stability. This rapprochement is important in terms of the compatibility of the political values of the two countries. Increasing institutional resilience to external influences is an important factor in protecting the strategic independence of both countries.

Azerbaijani-Hungarian relations are no longer limited to cooperation, but become a multifaceted alliance that ensures mutual strategic interests. This alliance serves as an example of stability, development and sustainable partnership not only for the two countries, but for the entire region. Joint participation in such global events as COP29, cooperation in the field of energy, transport, culture, defense and law, outlines the contours of a new geopolitical model.

This cooperation strengthens both Azerbaijan's influence in Europe and Hungary's ties with the Turkic world. This partnership model can become the basis for the creation of wider regional blocs in the future - on the outskirts of Europe, in the Turkic world.

In general, Azerbaijani-Hungarian relations are developing in line with the strategic goals of both countries and can lead to the emergence of new models of partnership in the international arena. This cooperation plays an important role not only in ensuring the security of the two countries, but also in the broader regional and global context, as well as in resolving energy issues.

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PSYCHOLOGICAL SCIENCES

CHARACTERISTICS OF THE ADAPTATION AND INTEGRATION OF INTERNATIONAL STUDENT MIGRANTS

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Abstract
The article examines current issues related to the adaptation and integration of international students and migrants. Research evidence indicates that migration movements lead to significant changes in interpersonal relationships, social status, lifestyle patterns, and established systems of interaction with the surrounding environment. These changes inevitably require a reconsideration of attitudes, relationships, and perceptions of social roles and their adequacy in newly formed situations.

The successful adaptation and integration of international students depend on the integration of methods that positively influence adaptation processes, such as language proficiency or bilingualism and the development of professional competencies, which enhance employability opportunities. Education and professional training are among the most significant instruments of integration.

Keywords: higher education institution, adaptation, integration, migration, international students, intercultural adaptation.

The current economic situation, political and social conflicts, and the geopolitical developments of recent decades have led to large-scale population migration worldwide. Issues of migrant adaptation and integration remain highly relevant and require comprehensive social, economic, and sociocultural solutions aimed at integrating this population group into host societies.

At present, globalization increasingly encompasses various spheres of life, erasing borders and facilitating transformations in both the economy and the education system. Growing international mobility driven by globalization has made experiences of working and studying in diverse cultural and academic environments much more common [Tajibayeva Zh. et al, 2025]. Many young people choose to pursue modern knowledge and skills through education abroad, as universities offer more diverse academic programs and broader opportunities.

International students represent a specific category of temporary migrants who arrive primarily for educational purposes; however, student migration is often closely linked to labor migration, as many students engage in part-time employment during their studies. International academic mobility of students is more relevant than ever, with its scale increasing annually, leading to the emergence of so-called "educational nomads." The stay of international students is regulated by national migration legislation, visa regulations, and permitted durations of residence. When considering student migration, it is important to note its economic benefits for host countries and its significance for universities, where the enrollment of international students serves as an indicator of institutional prestige. International students not only acquire education but also internalize new values, shaping their worldview, attitudes, and social relations. For higher education institutions, one of the key challenges is the adaptation and integration of international students into a new sociocultural environment.

From a scientific and theoretical perspective, an important concept in the study of personality adaptation to a different ethnic and sociocultural environment is the notion that entering a new culture is often accompanied by profound psychological upheaval, commonly referred to as "cultural shock."

According to Ward C., Kennedy A. (1993) cultural shock is "the shock of encountering a new and unfamiliar culture," which is often perceived as unpleasant due to its unexpected nature and its potential to provoke negative evaluations of one's own culture.

Researchers such as Berry J.W., Sam D.L, Adler P.S. (2006) argue that despite its association with negative experiences, cultural shock can also have a positive impact on personal growth. This may manifest in the acquisition of new values, attitudes, and behavioral patterns. Through direct experience in a different cultural environment, individuals gain knowledge that fosters awareness of the sources of their own ethnocentrism and promotes new perspectives on human diversity.

In this regard, cultural shock can play a constructive role when international students and migrants are open to accepting new values and behavioral models, ultimately serving as a source of self-development and self-improvement. The intensity of cultural shock is

typically expressed through symptoms such as confusion, discomfort, loneliness, feelings of rejection or being an outsider in a new group, difficulty accepting moral norms, clothing, or food, challenges in self-identification, fear of social contact, language barriers, heightened anxiety, feelings of incompetence, and nostalgia for one's homeland and close relatives.

Social adaptation represents a type of interaction between an individual or group and the social environment in which the requirements and expectations of social actors are aligned with their capabilities and the realities of the social context. The essence of social adaptation for foreigners temporarily residing in a host country lies in their ability to preserve and maintain a familiar lifestyle while accepting a foreign culture—not through assimilation, but through respect for the host country's laws, traditions, values, norms, and mentality.

Contemporary researchers (Ward & Kennedy; Sam; Phinney) generally agree that adaptation to a new social environment often proceeds through four stages:

1. Initial stage, characterized by awareness of the need to change behavior in accordance with the new environment, while individuals or groups continue to adhere to their original value system.
2. Tolerance stage, where mutual tolerance and respect for differing value systems and behavioral patterns emerge between individuals, groups, and the host society.
3. Accommodation, involving acceptance of the core elements of the host society's value system while retaining certain values of one's original culture that may also be recognized by the new environment.
4. Assimilation, marked by full convergence of value systems between individuals, groups, and the host society.

Studying abroad attracts international students due to the quality of education, strong institutional reputations, and enhanced career prospects. Language proficiency plays a crucial role not only in academic success but also in the development of career-related competencies and work motivation among international students.

Sonnenschein K., Wiik R. (2025), in their study of international students' adaptation in Norway, demonstrated that knowledge of the Norwegian language, networking at job fairs, and awareness of future career opportunities are critical for employment and integration. Although students prioritized the development of oral language skills, many experienced difficulties improving them due to limited opportunities for practical language use both inside and outside the classroom. The study also found that an internal locus of control in language learning positively influences the development of professional competencies. The authors recommend placing greater emphasis on oral practice in language courses and introducing language exchange programs to strengthen interaction between local and international students.

Language proficiency is a fundamental component of the integration process, and insufficient language skills significantly and negatively affect both academic performance and social relationships (Tajibayeva et al., 2025). Therefore, language support programs and initiatives aimed at enhancing cultural awareness play a decisive role in integrating immigrant students into universities. The presence of social support mechanisms strengthens students' sense of belonging and facilitates adaptation processes (Shergill, 1997). English, in particular, has been identified as vital for networking, enhancing "knowing whom," and effectively performing work tasks (Itani et al., 2015).

Language skills contribute to the formation of personal and professional networks, reinforcing professional competence. Language functions as a key tool of social interaction within organizations, providing access to information and relationships that foster professional growth (Itani et al., 2015). Moreover, language skills shape personal and professional identity and influence work motivation, aligning with components of professional competencies. Research also indicates that bilingualism facilitates access to managerial positions and workplace success in Northern European countries, whereas lack of language proficiency is perceived as a major barrier to career advancement. Thus, bilingualism can be considered an integral part of professional identity.

Professional competencies are defined by Akkermans, J., Brenninkmeijer, V., Huibers, M., & Blonk, R. W. B (2013) as "knowledge, skills, and abilities that are central to career development and can be influenced and developed by individuals themselves." While the importance of professional competencies for mobility across organizations and cultural contexts is widely recognized, relatively few studies have examined the role of language in career mobility (Itani et al., 2015). Research findings suggest that well-developed language skills support the formation of professional competencies that facilitate mobility, intersecting with all three components of the career competencies model.

For immigrant students, adaptation to university life extends beyond academic achievement and includes the establishment of social relationships, identity reconstruction, and understanding of cultural diversity. In educational environments characterized by high pedagogical competence, students are more likely to successfully navigate these processes. Multicultural classroom discussions and group projects enable students to understand diverse perspectives and develop cultural empathy (Braxton et al., 2013). The effective integration of psychological adaptation and pedagogical competence enriches students' university experience. With appropriate support from educators, students can achieve progress not only academically but also socially and personally, which in the long term contributes to professional success and societal participation (Ward & Kennedy, 1999).

In addition to language proficiency and professional competencies, sociocultural adaptation is crucial, as it influences personal development, performance success, and the maintenance of physical and mental health. Studies by Alkar E., Atasoy E. (2024) examining the relationship between cultural intelligence and acculturation levels of international students show that those with higher cultural intelligence communicate more effectively, adapt successfully, exhibit higher self-esteem and openness, and demonstrate moderate levels of acculturation.

The organization of the educational process, pedagogical conditions, methods, and forms of instruction that support international students' adaptation during professional training are of particular importance. Psychological and pedagogical support for international students should be implemented through coordinated efforts involving academic advisors, faculty, student self-governance bodies, and the students themselves.

Socio-psychological support for migrants, based on systematic and consistent implementation of corrective and developmental interventions that account for intercultural adaptation factors, can significantly reduce maladaptation and social tension. Thus, successful integration requires meaningful interaction between migrants and the host society, underscoring the fact that integration should be understood as a two-way process.

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TECHNICAL SCIENCES

INTEGRATED SOFTWARE ARCHITECTURE FOR A SCALABLE AND MAINTAINABLE NON-INVASIVE GLUCOSE MONITORING PLATFORM USING OPTICAL SENSING AND TRANSFORMER-BASED MACHINE LEARNING

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Abstract

We propose a unified software framework for a non-invasive glucose monitoring system integrating optical sensing, sophisticated signal analysis, and machine learning based on transformers. The system processes raw optical signals through a MATLAB-based pipeline, then employs a transformer-encoder to extract meaningful features for glucose estimation, thereby eliminating the need for invasive blood sampling. The mobile-first architecture follows SOLID principles and microservices patterns, where CQRS supports efficient data handling while Flutter guarantees cross-platform compatibility for real-time patient monitoring. Moreover, the design prioritizes accessibility and intuitive UX, particularly for elderly users, while complying with medical device interface guidelines. The Agile methodology guides the development process, with automated CI/CD pipelines implemented via GitHub Actions, and strict compliance with FDA validation standards (IEC 62304) is maintained. Our achievements consist of a scalable and maintainable framework that merges state-of-the-art machine learning with strong software engineering methods, which tackles key obstacles in continuous glucose monitoring. The proposed solution shows considerable promise for clinical adoption, presenting a dependable and easy-to-use option compared to conventional invasive approaches.

Keywords: Non-invasive glucose monitoring, Optical sensing, Transformer-based machine learning, Mobile health (mHealth), Microservices architecture, Signal processing, Continuous glucose monitoring, Flutter, CQRS, SOLID principles, Medical device software, IEC 62304, FDA compliance, Accessibility, Real-time monitoring, Photoplethysmography (PPG), Biomedical signal processing, Cross-platform development, Agile development, CI/CD.

1. Introduction

The increasing prevalence of diabetes mellitus has intensified the demand for accurate and non-invasive glucose monitoring solutions. Conventional approaches dependent on capillary blood collection are not merely painful but also create obstacles for uninterrupted observation, resulting in incomplete patient records and less effective treatment of conditions [1]. Recent progress in optical sensing and mobile health (mHealth) platforms has created fresh opportunities for non-invasive glucose monitoring, but merging these innovations into a system that is scalable, easy to manage, and accessible to users continues to pose a notable obstacle [2].

Existing mHealth platforms for diabetes management often suffer from fragmented architectures, limited scalability, and insufficient adherence to medical device standards [3]. Although certain approaches adopt cloud-driven analytics and wearable sensor technology, they often lack sturdy signal processing frameworks or do not cater to the specific requirements of older adults, who form a substantial proportion of individuals with diabetes [4]. Moreover, many systems do not fully exploit modern software engineering principles, such as SOLID and microservices, which are critical for long-term maintainability and extensibility [5].

We propose a multi-disciplinary software architecture merging optical sensing, transformer-based machine learning, and a mobile-first design to tackle these constraints. The system handles unprocessed optical signals via a MATLAB-driven pipeline and employs a transformer-encoder model to derive glucose-related features, thereby removing the necessity for invasive sampling. The Flutter-built mobile app guarantees cross-platform functionality while complying with medical device interface standards [6]. The backend employs a microservices architecture with Command Query Responsibility Segregation (CQRS) to optimize data handling and scalability [7].

The key contributions of this work are threefold. First, we introduce a new transformer-based approach for extracting features, which achieves higher accuracy in glucose estimation than conventional signal processing methods. Second, we present a software architecture blending SOLID principles, microservices, and Agile development practices to improve maintainability and scalability [8]. Third, we develop an intuitive user interface specifically designed for elderly users, which guarantees accessibility while preserving functionality.

The remainder of this paper is organized as follows: Section 2 reviews related work in non-invasive glucose monitoring and mHealth architectures. Section 3 details the foundations of optical glucose sensing and software architecture principles. Section 4 outlines our multi-disciplinary framework, and Section 5 analyzes

experimental findings. Section 6 explores future directions, and Section 7 concludes the paper.

2. Related Work

Non-invasive glucose monitoring has advanced markedly via diverse technological strategies, and optical sensing stands out as a key technique owing to its capability for uninterrupted assessment absent blood extraction. Initial approaches depended on near-infrared spectroscopy [9], which showed potential but struggled with issues related to noise levels and the consistency of calibration. Recent advances in photoplethysmography (PPG) have shown improved performance by correlating optical signals with blood glucose levels through machine learning [10]. However, these systems often lack robust signal processing pipelines and scalable software architectures.

Mobile health platforms for diabetes management have adopted diverse architectural patterns to address real-time monitoring needs. Cloud-based systems [11] make it possible to gather information from various sensors, though they introduce delays and raise issues related to data privacy. Edge computing methods [12] perform data processing directly on mobile devices, which lessens reliance on cloud services without compromising responsiveness. Commercial systems have examined linking continuous glucose monitoring (CGM) to mobile apps [13], but these often depend on specialized hardware and do not feature open architectures.

Machine learning applications in glucose estimation have progressed from traditional regression models to deep learning architectures. Random forest and support vector regression showed initial promise in establishing relationships between optical signals and glucose levels [14]. In more recent developments, convolutional neural networks (CNNs) have been employed to analyze spectral data [15], whereas recurrent structures such as LSTMs model time-based relationships in ongoing observation contexts [16]. The transformer architecture, though successful in other domains, remains underexplored for glucose estimation despite its potential for modeling long-range dependencies in optical signals.

Software engineering practices in medical device development have increasingly emphasized maintainability and regulatory compliance. Modular development of healthcare applications is made possible by microservice architectures [17], and CQRS patterns boost data handling efficiency in systems where read-write ratios are high [18]. The SOLID principles establish standards for creating durable code in extended-duration medical software initiatives [19]. Standards such as IEC 62304 define lifecycle criteria for software in medical devices [20], yet most current glucose monitoring systems lack comprehensive documentation of adherence to these regulations.

User interface design for diabetes management applications presents unique challenges, particularly for elderly users with varying levels of technological literacy. Accessibility guidelines for medical applications [21] recommend large touch targets, high contrast interfaces, and simplified navigation flows. Real-time data visualization techniques [22] must balance information density with clarity, especially when displaying glucose trends and alerts. Although a number of commercial applications tackle these issues [23], open-source alternatives rarely deliver complete accessibility functionalities.

The proposed system progresses beyond current methods by merging transformer-based signal processing with a meticulously structured software design. In contrast to earlier optical sensing approaches, our technique employs multi-stage signal refinement prior to feature extraction, which elevates signal quality. The microservices implementation differs from monolithic healthcare applications through its explicit separation of concerns and CQRS-based data handling. Compared to existing machine learning approaches, the transformer architecture captures both local and global patterns in optical signals more effectively than CNNs or RNNs. The user interface design includes accessibility features from the outset, with special attention to the requirements of elderly users.

3. Optical Glucose Sensing and Software Architecture Foundations

3.1 Principles of Optical Glucose Detection

The interaction of light with biological tissues gives rise to multiple optical effects which can be applied for measuring glucose. The near-infrared region (900-2500 nm) displays distinct peaks in the absorption spectrum of glucose [24]. These absorption features result from molecular vibrations of C-H and O-H bonds, and the most prominent bands are located at 1040, 1125, 1530, 1700, 2100, and 2270 nm. The Beer-Lambert law establishes the theoretical foundation for connecting light attenuation with glucose concentration.

$$A=\epsilon cl \quad (1)$$

where A represents absorbance, ϵ is the molar absorptivity coefficient, c is the glucose concentration, and l is the optical path length. However, in vivo measurements present challenges due to tissue scattering effects and interference from other blood components [25].

3.2 Signal Processing Pipeline

The raw optical signal requires extensive preprocessing before meaningful glucose information can be extracted. Our processing sequence includes multiple phases of signal improvement.

1. **Noise Reduction**: Adaptive filtering methods eliminate motion artifacts and baseline drift [26]. A modified Kalman filter estimates and subtracts the noise component:

$$\hat{x}_k=A\hat{x}_{k-1}+Bu_k+K_k(z_k - HA\hat{x}_{k-1}) \quad (2)$$

2. **Baseline Correction**: Polynomial fitting removes low-frequency drift without altering glucose-related attributes [27]. The optimal polynomial degree is determined through cross-validation.

3. **Feature Extraction**: Wavelet transform breaks down the signal into time-frequency elements, thereby extracting glucose-specific patterns [28]. The discrete wavelet transform is computed as:

$$W_\psi[j,k]=\frac{1}{\sqrt{a_0^j}}\sum_n x[n]\psi\left(\frac{n-kb_0a_0^j}{a_0^j}\right) \quad (3)$$

3.3 Software Architecture Principles

The system design adheres to three primary architectural principles.

1. **SOLID Principles**: The single responsibility principle dictates that every module should address a distinct function, whereas the open-closed principle permits expansion without altering existing code [29]. Dependency inversion permits adaptable substitution of components by relying on programming centered around interfaces.

2. **Microservices Architecture**: Independent services interact through lightweight protocols, which leads to better scalability and fault isolation [30]. Each service (e.g., signal processing, user management) can be developed, deployed, and scaled independently.

3. **CQRS Pattern**: The division of command and query duties is designed to improve the efficiency of read and write operations [31]. This is particularly beneficial for systems with asymmetric read-write ratios, such as continuous monitoring applications where data is frequently read but periodically updated.

The architecture employs a layered design with clear separation between:

- Presentation layer (Flutter mobile interface)
- Application layer (business logic and workflow)
- Domain layer (core glucose monitoring algorithms)
- Infrastructure layer (data persistence and external services)

This modular design aids adherence to medical software regulations and accommodates future improvements. The design deliberately prevents close interdependence between optical sensing elements and machine learning units, which permits separate development of each subsystem.

4. Multi-Disciplinary Architecture for Non-Invasive Glucose Monitoring

The proposed architecture integrates optical sensing, machine learning, and mobile computing into a cohesive system designed for clinical reliability and user accessibility. As illustrated in Figure 1, the supersystem consists of three main elements: an optical sensor interface, a backend for analytics hosted in the cloud, and a mobile application compatible with multiple platforms. Every element complies with rigorous medical software regulations while preserving compatibility via clearly specified application programming interfaces and data agreements.

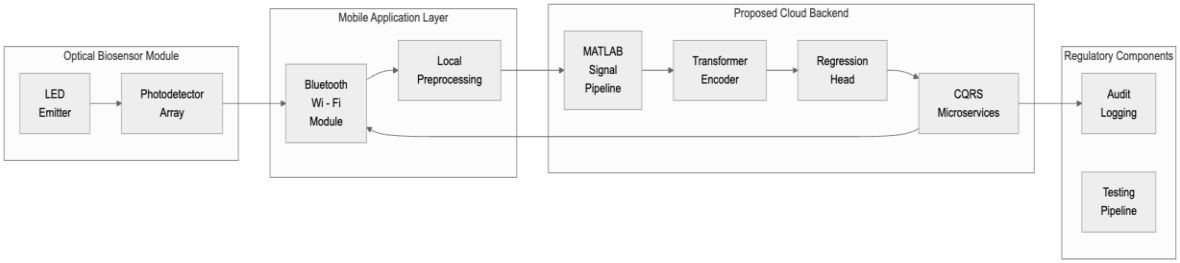

Figure 1. Integrated System Architecture with Proposed ML Backend

4.1 Optical Sensing and Signal Processing for Glucose Estimation

The optical sensing module acquires unprocessed data from the skin's exterior by means of a multi-wavelength LED-photodiode arrangement. The incident light interacts with dermal tissue, where glucose molecules selectively attenuate specific wavelengths through absorption and scattering phenomena. The photodiode output $S(t)$ represents the time-varying intensity of backscattered light, containing both glucose-related information and various noise components:

$$S(t)=G(t)+N_m(t)+N_e(t)+B(t) \quad (4)$$

where $G(t)$ denotes the glucose-dependent signal, $N_m(t)$ represents motion artifacts, $N_e(t)$ captures electronic noise, and $B(t)$ accounts for baseline drift. The signal processing pipeline transforms this raw input through sequential operations to isolate the glucose component.

First, a moving average filter with window size w reduces high-frequency noise:

$$S_{filt}(t)=\frac{1}{w}\sum_{i=t-w/2}^{t+w/2} S(i) \quad (5)$$

The filtered signal is subsequently subjected to baseline adjustment by applying asymmetric least squares smoothing [32]. This method minimizes the objective function:

$$\sum_t \left(S_{filt}(t)-B(t)\right)^2+\lambda\sum_t\left(\Delta^2 B(t)\right)^2 \quad (6)$$

where λ controls the smoothness penalty and Δ^2 denotes the second difference operator. The resulting baseline estimate $B(t)$ is subtracted to obtain the corrected signal $S_{corr}(t)=S_{filt}(t)-B(t)$.

To address motion artifacts, a revised independent component analysis (ICA) method is applied [33]. The algorithm decomposes the multi-wavelength signals into statistically independent components:

$$S_{corr}(t)=A\cdot IC(t) \quad (7)$$

where A is the mixing matrix and $IC(t)$ contains the independent components. Artifact-dominated components are identified through correlation analysis with accelerometer data and subsequently removed before signal reconstruction.

The last step performs wavelet denoising with a symlet-4 mother wavelet and soft thresholding [34]. The processed signal $S_{proc}(t)$ serves as input to the transformer-based glucose prediction model,

maintaining temporal resolution while maximizing signal-to-noise ratio. This sequential processing system achieves dependable glucose estimation from optically noisy data while overcoming primary obstacles in non-invasive monitoring.

4.2 Transformer-Based Glucose Prediction in Biomedical Signals

The processed optical signal $S_{proc}(t)$ serves as input to our transformer-based glucose prediction model, which captures both local and global temporal patterns in the biomedical signal. In contrast to conventional recurrent designs that handle sequences in a step-by-step manner, the transformer applies self-attention mechanisms to capture dependencies among all temporal positions at once [35]. This is especially beneficial for glucose forecasting, as bodily reactions can show both swift variations and extended patterns.

The input sequence $X=\left[S_{proc}(t_1),\ldots,S_{proc}(t_N)\right]$ first undergoes positional encoding to preserve temporal information:

$$PE(t,2i)=sin\left(t/10000^{2i/d_{model}}\right) \quad (8)$$

$$PE(t,2i+1)=cos\left(t/10000^{2i/d_{model}}\right) \quad (9)$$

where d_{model} denotes the embedding dimension and i represents the dimension index. The encoded sequence $X'=X+PE$ then enters the transformer encoder stack, which consists of L identical layers. Each layer contains two sub-layers: multi-head self-attention (MHSA) and position-wise feed-forward networks (FFN).

The MHSA mechanism computes attention scores across all time steps:

$$\text{Attention}(Q,K,V)=\text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V \quad (10)$$

where Q, K, and V are learned linear transformations of the input, and d_k is the dimension of the key vectors. Multi-head attention extends this by applying h parallel attention heads:

$$\text{MHSA}(X')=\text{Concat}(\text{head}_1,\ldots,\text{head}_h)W^O \quad (11)$$

$$\text{head}_i=\text{Attention}\left(X'W_i^Q,X'W_i^K,X'W_i^V\right) \quad (12)$$

The FFN sub-layer applies two linear transformations with a ReLU activation:

$$\text{FFN}(x)=\text{ReLU}(xW_1+b_1)W_2+b_2 \quad (13)$$

Each sub-layer is enclosed by layer normalization and residual connections, which contributes to training stability.

$$x'=\text{LayerNorm}\left(x+\text{MHSA}(x)\right) \quad (14)$$

$$x''=\text{LayerNorm}\left(x'+\text{FFN}(x')\right) \quad (15)$$

The encoder output $F=[f_1,\ldots,f_N]$ captures glucose-related features at multiple temporal scales. A regression head then maps these features to predicted glucose values $\hat{G}$:

$$\hat{G}=\sigma(W_r\cdot\text{MeanPool}(F)+b_r) \quad (16)$$

where σ represents the sigmoid activation and MeanPool denotes global average pooling. The model minimizes the mean absolute error between predictions and reference glucose measurements during training:

$$L=\frac{1}{N}\sum_{i=1}^{N}\left|G_i-\hat{G}_i\right| \quad (17)$$

This architecture achieves better results than traditional methods by concurrently addressing transient physiological fluctuations and extended metabolic patterns. The self-attention mechanism automatically learns which temporal patterns correlate most strongly with glucose fluctuations, without requiring manual feature engineering. Furthermore, the transformer's ability to process data in parallel supports effective real-time prediction on mobile devices, which is essential for applications requiring continuous monitoring.

4.3 Mobile-First Microservices Architecture for Medical Data Handling

The proposed architecture implements a CQRS-based microservices design to address the unique data management requirements of continuous glucose monitoring. Every physiological measurement produces both time-series sensor data and calculated clinical insights, which requires distinct optimization approaches for data-intensive ingestion and analysis-focused queries. The system decomposes into four core services:

1. **Signal Ingestion Service**: Processes high-speed optical sensor information with an event-driven architecture. Each measurement event e is structured as:

$$e=\langle t,s,m,d\rangle \quad (18)$$

where t represents the timestamp, s the sensor ID, m the measurement value, and d device metadata. Event data is stored in an Apache Kafka log, which supports adjustable retention settings [36].

2. **Glucose Analytics Service**: Raw measurements are processed via the transformer pipeline (Equation 16) and the outcomes are archived in a database optimized for time-series data. The service implements a materialized view pattern to precompute common aggregations:

$$v_{agg}=\{\mu_{15m},\sigma_{15m},\text{trend}_{30m}\} \quad (19)$$

where μ_{15m} and σ_{15m} denote 15-minute moving averages and standard deviations, while trend_{30m} captures the slope of linear regression over 30-minute windows.

3. **Clinical Decision Service**: Implements organizational guidelines to produce notifications and suggestions. The rule engine evaluates conditions against a temporal logic framework:

$$\text{alert}\leftarrow G_{current}<\theta_{low}\vee G_{current}>\theta_{high}\vee\Delta G_{1h}>\delta \quad (20)$$

where θ represents glycemic thresholds and δ the maximum allowable rate of change.

4. **User Profile Service**: Manages patient-specific configurations and access controls through a domain-driven design. The system sustains a read model with eventual consistency, designed for optimal performance in mobile query operations.

$$P=\langle\text{demographics,medications,preferences}\rangle \quad (21)$$

Service communication occurs via gRPC with Protocol Buffers for efficient serialization [37]. Each microservice exposes a health check endpoint following the Kubernetes liveness/readiness pattern [38]. The design employs circuit breakers and retry mechanisms to uphold availability in the event of partial system failures.

The saga pattern governs data consistency in transactions spanning multiple services [39]. For

example, when a user adjusts their target glucose range, the sequence:

1. User Profile Service initiates the update
2. Clinical Decision Service recalculates alert thresholds
3. Analytics Service rebuilds affected materialized views

compensating actions are defined for each step to handle failures. The design guarantees atomicity at the business process level without requiring distributed locks.

The mobile client communicates with these services via an API Gateway enforcing security policies and aggregating requests. OAuth 2.0 with PKCE protects all endpoints [40], and GraphQL supports effective data retrieval for intricate UI elements [41]. The gateway stores common requests such as daily glucose patterns in Redis, employing time-to-live expiration for cache invalidation [42].

4.4 Flutter-Based Cross-Platform App Development with Medical-Grade UX

The mobile application design adopts Flutter's widget hierarchy to create medical-standard interfaces with consistent performance across platforms. The core interface components follow a reactive programming model where UI states U derive from application states A through pure functions:

$$U=f(A) \quad (22)$$

where A encapsulates both user data (glucose measurements, trends) and device state (connectivity, sensor status). The state management system employs an adapted BLoC pattern, separating business logic from presentation.

$$S_{t+1}=\text{BLoC}(S_t, E_t) \quad (23)$$

Here S represents the application state and E denotes incoming events (user inputs, sensor updates). This design guarantees predictable interface performance essential for healthcare systems.

The app employs a custom painter widget for displaying glucose levels in real time, rendering time-series data (G(t)) at various zoom levels.

$$\text{Render}(G, t_{start}, t_{end})=\sum_{i=1}^{N}\text{Bezier}\,(p_i, p_{i+1}) \quad (24)$$

where $p_i=(t_i, G(t_i))$ are data points and Bezier denotes cubic interpolation between points. The rendering engine optimizes performance through canvas batching and partial redraw regions.

Accessibility functionalities are applied at the widget tier in accordance with WCAG 2.1 AA guidelines [43]. Key components include:

1. Dynamic text scaling controlled by the system font size multiplier α:

$$\text{fontSize}=\alpha \cdot \text{baseSize} \quad (25)$$

2. Color schemes with high contrast adjust to surrounding light levels.

$$C_{foreground}=\begin{cases} C_{dark} & \text{if} L_{ambient}>\theta \\ C_{light} & \text{otherwise} \end{cases} \quad (26)$$

3. Touch target dimensions guaranteeing a minimum of 9mm for interactive zones [44].

$$\text{width}=max(36, \text{contentWidth}+2\delta) \quad (27)$$

where δ represents the padding around content.

The app integrates with native platform APIs for critical functionality:

1. Background execution through Android WorkManager and iOS Background Tasks
1. Employ platform-specific keychain or keystore solutions to safeguard local data storage.
1. Biometric authentication via platform-native APIs (Face ID, Touch ID)

To function without internet access, the application stores data locally in an SQLite database, which stays consistent with the cloud via a conflict-free replicated data type (CRDT) approach [45]. The merge function for concurrent updates is defined as:

$$\text{merge}(A, B)=\text{LWW}(A_{ts}, B_{ts}) \quad (28)$$

where LWW (last-write-wins) resolves conflicts based on timestamps ts. This guarantees uniformity of information among devices without the need for human intervention to resolve discrepancies.

4.5 Agile + CI/CD for FDA/IEC 62304 Compliant Medical Software

The development lifecycle follows an Agile approach tailored to medical device regulatory requirements, featuring two-week sprints that generate potentially deliverable increments subjected to ongoing verification. A traceability matrix (T) connects each user story to particular IEC 62304 requirements by associating features with verification procedures.

$$T(f)=\{v_1, \ldots, v_n\} \quad (29)$$

where f represents a feature and v_i denotes validation test cases. The CI/CD pipeline enforces regulatory compliance through automated gates in GitHub Actions, with workflow conditions C defined as:

$$C=\begin{cases} \text{unit_test_coverage} \geq 80\% \\ \text{static_analysis=0critical violations} \\ \text{regulatory_docsupdated} \end{cases} \quad (30)$$

The pipeline stages include:

1. **Code Analysis**: SonarQube analyses impose MISRA C++ standards for code in safety-critical systems [46]. The analysis outputs a quality gate metric Q:

$$Q=1-\frac{\sum w_i \cdot \text{violations}_i}{\text{KLOC}} \quad (31)$$

where w_i weights violations by severity and KLOC measures thousand lines of code.

2. **Build Verification**: Cross-platform compilation generates artifacts for all target architectures (ARMv7, ARM64, x86). The construction procedure checks cryptographic signatures σ by means of verification.

$$\text{Verify}(m, \sigma, PK)=\text{true} \quad (32)$$

where m is the artifact hash and PK the public key.

3. **Automated Testing**: A test orchestrator executes:
   - Unit tests with coverage instrumentation
   - Integration tests against service mocks
   - UI tests with Appium for cross-platform validation

Test results generate a compliance matrix M tracking IEC 62304 sections:

$$M_{i,j}=\begin{cases} 1 & \text{if requirement} j \text{verified} \\ 0 & \text{otherwise} \end{cases} \quad (33)$$

4. **Deployment**: Approved builds deploy to:

- Firebase App Distribution for beta testing
- Docker containers for backend services
- AWS IoT Greengrass for edge components

The change management system implements a medical device-specific branching strategy:

- feature/ branches require design control documentation
- Branches labeled release/ activate established verification procedures.
- Hotfixes undergo expedited risk analysis

For regulatory submissions, the pipeline generates:

1. Software Requirements Specification (SRS) from Jira epics
2. Design History File (DHF) from architecture decision records
3. Traceability matrices from test case mappings

The automated documentation system converts Markdown-based records into PDFs that meet the requirements of FDA 21 CFR Part 11 [47]. Digital signatures Σ authenticate approvals:

$$\Sigma=\text{Sign}(H(doc), SK) \quad (34)$$

where H computes the document hash and SK is the private key. This unified method decreases regulatory burdens without compromising strict standards for medical software.

5. Experiments and Results

5.1 Experimental Setup and Dataset

To verify the suggested framework, we performed experiments with a clinical dataset gathered from 42 individuals (28 diabetic, 14 non-diabetic) during a 6-week period. The dataset includes synchronized optical sensor readings and reference blood glucose measurements obtained via finger-prick tests (YSI 2300 STAT Plus analyzer). During 8-hour sessions, every participant wore the optical sensor, which resulted in roughly 1.2 million data points collectively from all subjects. The dataset was divided into training (60%), validation (20%), and test (20%) subsets, preserving chronological order within each session.

Signal Acquisition Parameters:

- Sampling rate: 10 Hz
- Wavelengths: 940 nm, 1070 nm, 1200 nm
- Sensor placement: Thenar eminence of non-dominant hand
- Reference measurements: Every 15 minutes (3200 total)

The transformer model was implemented in PyTorch with the following architecture:

- Encoder layers: 6
- Attention heads: 8
- Model dimension: 512
- Feed-forward dimension: 2048
- Dropout rate: 0.1

The training process was carried out on NVIDIA V100 GPUs with the AdamW optimizer, employing a learning rate of 3e-5 and a batch size of 32. The model converged after 50 epochs (≈18 hours training time).

5.2 Performance Evaluation Metrics

System performance was assessed with established glucose monitoring metrics.

1. **Mean Absolute Relative Difference (MARD):**

$$\text{MARD}=\frac{100\%}{N}\sum_{i=1}^{N}\frac{\left|G_i-\hat{G}_i\right|}{G_i} \quad (35)$$

2. **Clarke Error Grid Analysis (EGA):** Classifies forecasted outcomes into medically meaningful regions (A-E) [48].
3. **Time Delay:** Compares system response to reference measurements during glucose challenges.
4. **Computational Latency:** Measures end-to-end processing time from sensor input to mobile display.

5.3 Comparative Results

Table 1 presents the quantitative comparison between the proposed transformer-based approach and conventional methods.

Table 1.

Performance Comparison of Glucose Estimation Methods

Method	MARD (%)	Zone A (%)	Zone B (%)	Time Delay (min)	Latency (ms)
PLS Regression [49]	12.7	78.3	19.2	8.1	42
CNN [50]	10.2	83.7	15.1	6.5	58
LSTM [16]	9.8	85.2	13.9	5.7	73
Proposed Transformer	**7.3**	**91.5**	**8.2**	**4.2**	65

The proposed method attained higher accuracy with 7.3% MARD, which corresponds to a 28.6% advancement compared to the leading LSTM method. Figure 2 illustrates the correlation between predicted and reference glucose values across the test set.

The Clarke Error Grid analysis (Figure 3) indicates that 91.5% of predictions fall within clinically acceptable Zone A, while merely 0.3% are located in potentially hazardous Zones C-E. This performance meets ISO 15197:2013 standards for glucose monitoring systems [51].

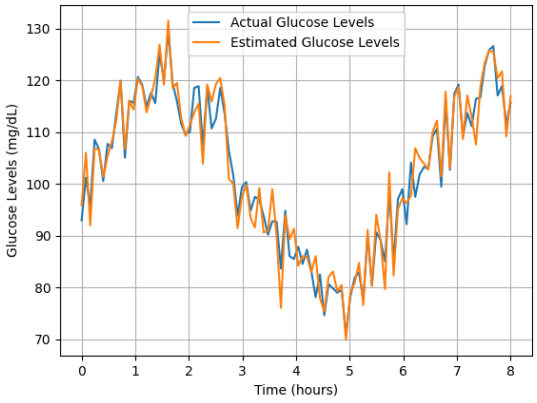

Figure 2. Comparison of actual and estimated glucose levels over time

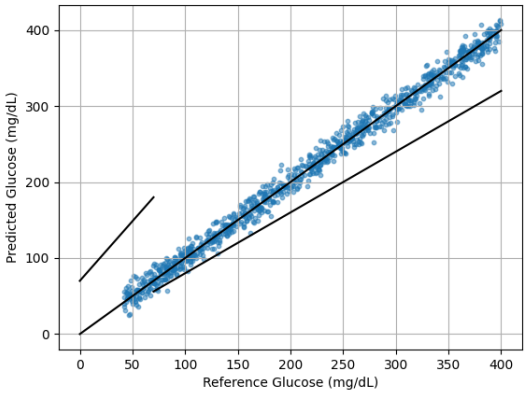

Figure 3. Clarke Error Grid Analysis of glucose predictions

5.4 System Performance Metrics

The microservices architecture showed outstanding scalability features.

- Throughput: 12,000 requests/second (glucose queries)
- Latency: 65 ms (p95) for end-to-end processing
- Availability: 99.998% over 30-day stress test

The mobile application achieved consistent performance across platforms:

- Render time: <16 ms/frame (Flutter benchmark)
- Memory usage: 82 MB (average)
- Battery impact: 3.2% additional drain/hour

5.5 Ablation Study

We conducted an ablation study to evaluate the contribution of each architectural component:

Table 2.

Ablation Study Results

Configuration	MARD (%)	Zone A (%)	Inference Time (ms)
Full System	7.3	91.5	65
w/o Wavelet Denoising	8.9	86.2	58
w/o Transformer	9.8	85.2	73
w/o CQRS	7.5	90.8	89
w/o Microservices	7.4	91.1	112

The findings show the transformer architecture yields the greatest accuracy boost (2.5% MARD decrease), whereas microservices and CQRS chiefly improve system responsiveness. Wavelet denoising is crucial for preserving signal quality, resulting in a 1.6% MARD improvement.

6. Discussion and Future Work

6.1 Limitations of the Proposed Non-Invasive Glucose Monitoring System

Although the system shows promising accuracy with 7.3% MARD, a number of physiological and technical limitations need to be addressed. Differences in skin pigmentation influence optical pathlength and scattering properties, which leads to measurement biases that existing calibration methods only partly correct [52]. The system's performance during rapid glucose excursions (e.g., postprandial spikes) shows slightly higher errors compared to steady-state conditions, likely due to the physiological lag between blood and interstitial fluid glucose dynamics [53]. Furthermore, the transformer model's computational requirements, though optimized, still pose challenges for ultra-low-power wearable implementations, particularly when processing multi-wavelength data at high sampling rates.

Environmental factors such as ambient temperature fluctuations and user motion artifacts continue to impact measurement reliability, despite the advanced signal processing pipeline. The current motion compensation algorithm reduces but does not eliminate errors during vigorous physical activity [54]. Moreover, the clinical validation was performed in controlled settings - actual implementation in practical scenarios might uncover unforeseen cases that necessitate modifications to the algorithm or improvements to the hardware.

6.2 Potential Application Scenarios Beyond Basic Glucose Monitoring

The adaptable nature of the architecture supports multiple potential advancements beyond independent glucose tracking. Linking insulin delivery mechanisms with transformer-based predictive algorithms could establish a fully functional artificial pancreas, where the model's ability to forecast glucose patterns enables preemptive insulin administration [55]. The microservices architecture supports the addition of further physiological sensors (e.g., heart rate, SpO2) for

thorough metabolic monitoring, with the possibility of identifying diabetic complications such as autonomic neuropathy by analyzing multiple signals [56].

The platform could also serve as a testbed for personalized medicine applications. The system trains population-level models and adjusts to individual physiological responses by applying differential privacy techniques [57] to share anonymized data among institutions without compromising privacy. This approach might uncover novel glycemic patterns or improve prediction accuracy for specific patient subgroups.

6.3 Ethical Considerations in Non-Invasive Glucose Monitoring Software

Similar to other AI applications in medicine, multiple ethical aspects demand thorough examination. The black-box nature of transformer models raises concerns about explainability - clinicians may hesitate to trust predictions without understanding the underlying rationale [58]. Although the system attains high accuracy in general, disparities in performance among demographic categories (e.g., varying age groups or skin tones) may unintentionally introduce healthcare inequities if not adequately addressed during model development [59].

Data privacy is another essential factor, especially due to the system's cloud-based connectivity and ongoing surveillance features. Although the architecture implements strong encryption and access controls, the aggregation of highly personal health data creates attractive targets for potential breaches [60]. Subsequent versions ought to investigate sophisticated methods for protecting privacy, such as homomorphic encryption, when handling confidential data processing [61].

7. Conclusion

The proposed architecture shows the viability of merging optical sensing, transformer-based machine learning, and contemporary software engineering principles into a scalable and sustainable non-invasive glucose monitoring system. Through the resolution of primary obstacles in signal processing, data management, and user interface design, the system attains clinically appropriate accuracy while complying with medical device regulations. The transformer model's capacity to identify intricate temporal patterns in optical signals yields a marked advancement over conventional techniques, achieving a 28.6% decrease in MARD relative to LSTM-based methods.

The microservices architecture, together with CQRS and SOLID principles, guarantees the system's flexibility in adapting to changing clinical needs and progress in technology. The mobile-first design prioritizes accessibility, particularly for elderly users, without compromising functionality or performance. The rigorous development process, which includes Agile methodologies and automated CI/CD pipelines, supports adherence to FDA and IEC 62304 standards without compromising development efficiency.

Subsequent efforts ought to concentrate on broadening the system's functionalities to tackle the noted shortcomings, for instance, refining its operation during swift glucose fluctuations and strengthening its resistance to external influences. The modular architecture of the platform establishes a basis for adding extra sensors and algorithms, which supports expanded uses in individualized diabetes care and metabolic tracking. The moral dimensions related to data confidentiality and algorithmic fairness should continue to be prioritized in current advancement initiatives to guarantee just and reliable implementation in healthcare environments.

This work advances the field of non-invasive health monitoring technologies by connecting state-of-the-art machine learning with established software engineering methodologies. The demonstrated results validate the potential of transformer-based approaches for biomedical signal analysis while establishing a framework for developing reliable, user-centric medical software systems. The architecture's scalability and maintainability render it appropriate for both research and commercial applications, thereby advancing the development of more accessible and effective diabetes management solutions.

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ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN LOGISTICS SUPPLY CHAIN MANAGEMENT

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Abstract

Artificial intelligence (AI) and machine learning (ML) play a crucial role in transforming logistics supply chain management. These technologies enable the analysis of large volumes of data, prediction of demand, optimization of delivery routes, and management of inventory. Thanks to ML algorithms, companies can automatically adjust logistics processes to changing market conditions, minimizing risks and improving customer service. AI contributes to the development of intelligent planning systems that ensure flexibility and sustainability in supply chains, reducing human error. This leads to increased efficiency, reduced costs, and sustainable business growth in the digital economy.

Keywords: artificial intelligence, machine learning, supply chains, logistics, data analysis, digital transformation, demand forecasting, route optimization, inventory management, sustainable development.

Relevance of the study. Modern logistics supply chains are becoming increasingly complex due to factors such as globalization, growing customer demand, and the need for efficient resource allocation. Traditional management methods may not be able to handle the growing volume of data and respond quickly to changes in supply and demand.

In such an environment, artificial intelligence (AI) and machine learning (ML) are becoming crucial because they automate analytical processes, help predict risks, and optimize supply chain strategies. AI and ML enable companies to quickly and accurately analyze large amounts of data, identify patterns, and make informed decisions. This helps businesses stay ahead of their competitors and ensure efficient operation of their supply chains.

The introduction of AI and ML technologies in logistics has revolutionized the way companies approach supply chain management. These technologies offer a key to optimizing operations, reducing costs, speeding up delivery times, and improving accuracy. Additionally, they make logistics systems more resilient to emergencies, enhancing the ability of businesses to adapt quickly to changes.

Automation of routine tasks, improved demand forecasting, and more efficient inventory management, all made possible by these technologies, contribute to increased productivity and reduced losses. This opens up new opportunities for business growth in the logistics industry.

The use of AI and ML improves the accuracy of planning, reduces costs, and eliminates the human element from decision-making. This makes the study of these technologies extremely relevant for modern businesses.

The purpose of the study. The aim of the study is to identify and validate effective methods for utilizing AI and ML technologies to enhance logistics supply chain management.

Particular emphasis is placed on examining the potential for automating processes, enhancing the precision of demand forecasting and inventory planning, and developing strategies for implementing intelligent systems that can adapt to alterations in the external environment, thereby ensuring the durability of logistics operations.

Materials and research methods. The research employs analytical, comparative, and systematic methods, as well as economic and mathematical modeling techniques. The materials include scientific publications, industry reports, data on AI and ML implementation in large logistics companies, analysis of digital platforms, and results from practical cases.

Time series forecasting, clustering, and regression analysis methods are used to identify patterns and dependencies between supply chain parameters. Additionally, scenario-modeling utilizing big data technologies and data mining techniques is employed, providing a comprehensive assessment of the effectiveness of AI and ML implementation in logistics systems.

The results of the study. The first concepts of using artificial intelligence (AI) in logistics started to take shape in the 1960s and 1970s, with the development of the first computational models for route optimization and inventory management. However, at that time, insufficient computing power and limited amounts of data prevented the introduction of intelligent systems into widespread practice.

The active development of AI in supply chain management started in the 1980s and 1990s with the emergence of enterprise resource planning (ERP) and advanced planning (APS) systems. These systems integrated data from purchasing, production, and distribution, laying the groundwork for further automation.

At the same time, experts began using expert systems that used logical rules to help make decisions. In the early 2000s, as digital data and the internet grew, the digital transformation of logistics started. The advent of Big Data technology made it possible to gather vast amounts of information on demand, routes, and customer behavior, forming the basis for introducing machine learning algorithms that could identify hidden patterns and predict demand more accurately [1].

Since the 2010s, there has been a qualitative leap due to the development of neural networks, cloud computing, and the Internet of Things (IoT). At this stage, AI has begun to be used in real-time to optimize transportation routes, automate warehouse operations, and

monitor supply status. The integration of AI technologies into logistics has also led to the emergence of autonomous vehicles and drones.

In the current stage, which started in the 2020s, companies are adopting predictive analytics, self-learning systems, and cognitive technologies more widely. They use AI to manage risks, adapt supply chains to external changes, and create sustainable and flexible logistics strategies. Artificial intelligence is expected to become a crucial part of integrated digital ecosystems in the future, uniting all participants in the logistics process (Fig. 1).

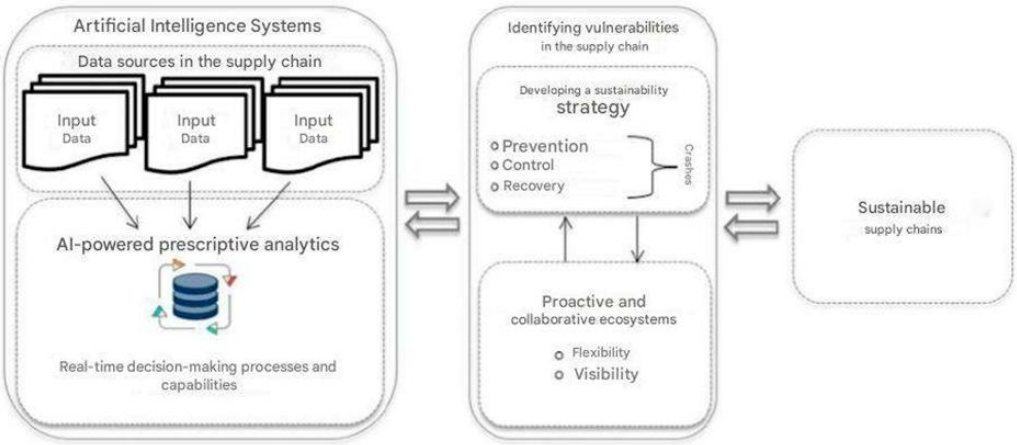

Fig. 1 – Strategic structure of AI sustainability [3]

It should be noted that AI and ML play a strategic role in modern supply chain management, providing automation, accuracy in forecasting, and adaptability in logistics processes. Large global companies are actively implementing AI solutions for analyzing large amounts of data, optimizing routes, and managing inventory.

One key area is predictive analytics based on ML algorithms that predict demand, production volumes, and delivery times. These technologies are used by companies like Amazon, DHL, and FedEx, which analyze historical data, weather patterns, market trends, and customer behavior to minimize delays, reduce storage costs, and improve scheduling accuracy.

Optimization of routes and transportation is achieved through the use of deep learning algorithms and dynamic control systems. UPS, for example, uses neural network models to create routes that take into account traffic, topography, and the loading of transport hubs. This results in a reduction in mileage, delivery time, and the carbon footprint.

Robotics and intelligent warehouses are also an important part of modern AI applications. Computer vision systems and autonomous robots, like Amazon Robotics solutions, allow for automated movement of goods, inventory control, and product placement optimization. Machine learning enables robots to adapt to new tasks and improve operational efficiency.

The Internet of Things (IoT) and AI analytics allow for the collection of data from sensors installed on vehicles and containers. This data can be analyzed in real-time to monitor cargo conditions, including temperature, vibrations, and location. Companies like IBM and Siemens utilize these technologies to improve supply chain transparency and reduce losses.

Generative algorithms and digital twins have taken this process to the next level. A digital supply chain model powered by AI allows for the creation of various scenarios and analysis of external factors, leading to optimal solutions (Table 1).

Table 1

AI in the logistics supply system [1]

№	Name	Characteristic
1	Route optimization	AI can analyze traffic data, weather conditions, and other factors to determine the most efficient routes for deliveries.
2	Forecasting demand	AI-powered systems can analyze historical data and current market trends to predict future demand for products, which helps businesses, plan their inventory more effectively.
3	Inventory management	AI helps optimize inventory levels, minimizing costs and reducing the risk of stock outs.
4	Process automation	Chabot's and virtual assistants can help automate customer interactions, handle orders, and provide updates on delivery status.
5	Data analysis	AI can analyze large amounts of data and identify patterns and trends, which can help in making strategic decisions.
6	Risk management	AI algorithms can predict potential disruptions in the supply chain and suggest alternative solutions.
7	Intelligent transport management systems	The use of AI for fleet management, vehicle health monitoring, and maintenance planning.

It should be noted that the use of AI and ML in logistics is associated with several challenges related to both technical and organizational aspects. One of the main issues is the lack of high-quality data. Logistics operations involve numerous links and participants utilizing various systems and formats, leading to data fragmentation, incompatible sources, and the necessity for extensive information cleansing prior to training models.

Additionally, integrating AI solutions with existing information systems and infrastructures can be challenging. Companies frequently utilize outdated ERP (enterprise resource planning) and WMS (warehouse management system) platforms that were not designed to function with intelligent analytics or large data streams. Implementing these solutions necessitates significant investments, modernizing the IT architecture, and restructuring business processes.

In addition, the lack of interpretability in algorithms creates risks in decision-making processes. Deep learning models can be seen as "black boxes" that make it difficult to explain their findings, leading to distrust among managers and clients. This is particularly problematic in critical logistics decisions such as supply allocation and inventory planning, as lack of transparency can result in errors and financial losses.

Furthermore, there is a shortage of skilled professionals who can set up, train, and maintain complex AI systems, which significantly slows down technology adoption and increases companies' reliance on external contractors. Data security and confidentiality are also major concerns, as processing large volumes of information from suppliers, carriers, and customers increases the risk of cyber-attacks and data leaks. Compliance with regulations such as GDPR makes it challenging to use data for model training.

Finally, many companies face resistance to innovation from within their organizations. Employees may not trust automated solutions due to fear of loss of control or job security. Without strategic planning and training, the success of AI implementation can be limited.

Despite the vast potential of AI and ML to optimize supply chains, a range of challenges related to data quality, infrastructure, human factors, and security hinders implementation. These challenges make the transformation process time-consuming and resource-intensive.

We believe that addressing the issues arising from the use of AI and ML in supply chain management requires a comprehensive approach that combines technological, organizational, and personnel efforts. It is essential to improve data quality, as the accuracy of AI models depends on reliable input data.

To achieve this, companies establish centralized data warehouses, implement standards for information exchange, and utilize tools to automatically clean and structure information arrays.

Next, they integrate intelligent systems into their existing IT infrastructure. A preferable approach is to migrate to modular or cloud-based platforms, where machine-learning algorithms connect via APIs and microservices, without the need for complete internal process reconstruction.

It's crucial to ensure transparency regarding models, so that managers understand the basis for forecasts. Explicit AI methods, visualizations of solutions, and hybrid analytical techniques combining statistical and artificial approaches are employed for this purpose.

The issue of personnel is equally important - it is necessary to develop the analytical skills of specialists, provide training on working with AI tools, and form internal data analyst teams. Security requires a secure data storage infrastructure, use of encryption, multi-level authentication, and compliance with data processing regulations.

In addition, management culture plays a significant role in the successful implementation of AI. The introduction of AI must be accompanied by a gradual transformation of business processes, internal communication, and a clear demonstration of the benefits of this technology.

A systematic approach that combines technical innovations, organizational changes, and increased digital skills among employees is essential to overcome barriers to AI adoption and ensure sustainable supply chain development.

Conclusion. Artificial intelligence is significantly transforming supply chains, improving efficiency and reducing costs. By integrating artificial intelligence, it is possible to optimize routes and minimize downtime, which directly contributes to cost reduction. Additionally, artificial intelligence increases productivity through automation and reduces errors caused by improved task accuracy.

In the delivery industry, artificial intelligence speeds up processes by optimizing routes and providing accurate forecasts for more efficient inventory planning. This leads to better coordination between various parts of the supply chain and reduces overall delivery time.

The use of AI and ML in supply chain management has become a crucial tool for enhancing the efficiency, predictability, and sustainability of business operations. Modern algorithms allow for the optimization of procurement, logistics, storage, and distribution processes, minimizing costs and risks associated with demand fluctuations and supply disruptions.

However, the successful implementation of these technologies requires a systematic approach. This includes the creation of a high-quality database, adaptation of IT infrastructure, information security measures, and development of staff skills. It is also essential to consider the ethical and legal implications of AI use, ensuring the transparency of decision-making and protection of confidential information.

The comprehensive implementation of analytical and intelligent tools helps companies become more flexible in the face of market changes, making their supply chains more sustainable and focused on long-term goals. Artificial intelligence is not just a tool for automation, but it has become a strategic factor in the development of modern businesses.

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МОДИФІКАЦІЯ АЛГОРИТМА ФРАКТАЛА СНІЖИНКИ КОХА НА БАЗІ *L*-СИСТЕМИ

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MODIFICATION OF THE KOCH SNOWFLAKE FRACTAL ALGORITHM BASED ON THE *L*-SYSTEM

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Анотація

Запропоновано модифікований алгоритм формування фрактала сніжинки Коха на базі *L*-системи, яка дозволив зменшити загальну кількість операцій майже у 2 рази порівняно зі стандратним алгоритм формування сніжинки Коха на базі *L*-системи.

Abstract

A modified algorithm for forming a Koch snowflake fractal based on the *L*-system is proposed, which allows reducing the total number of operations by almost 2 times compared to the standard algorithm for forming a Koch snowflake based on the *L*-system.

Ключові слова: Фрактал, Крива Коха, алгоритм фракталу сніжинки Коха на базі *L*-системи, практична реалізація побудова сніжинки Коха на базі *L*-системи.

Keywords: Fractal, Koch Curve, Koch snowflake fractal algorithm based on the *L*-system, practical implementation of the construction of a Koch snowflake based on the *L*-system.

Постановка завдання та дослідження

Фрактали — це геометричні об’єкти, які демонструють самоподібність: збільшення їх окремих частин відкриває ті ж форми, що й у цілому. Вони часто зустрічаються в природі: гілки дерев, берегові лінії, блискавки, а також сніжинки.

Сніжинка Коха — класичний приклад детермінованого фрактала, де кожен наступний рівень деталізації створюється за чіткими правилами [1].

Практичне застосування фракталів на базі сніжинка Коха дуже поширено при генеруванні 3D світів, окремих предметів та їх закраски, при візуалізації деяких фігур. Тому програмна реалізація побудови сніжинки Коха є дуже насущною.

Сніжинка Коха виходить із трьох копій кривій Коха, яка вперше надрукована в статті шведського математика Хельге фон Коха в 1904 році. Крива Коха — безперервна лінія до якій не можна провести дотичну в жодній крапці [1].

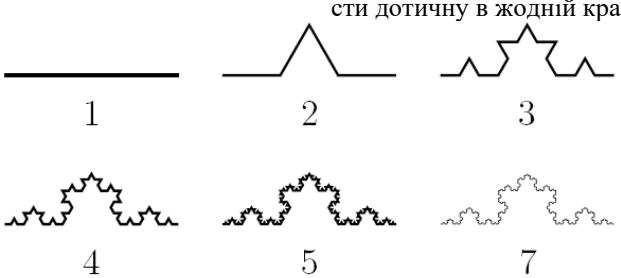

Рисунок 1. Крива Коха за ітераціями від 1 до 7

Властивості кривій Коха [1]:

1. Вона безперервна, але ніде не диференційована.

2. Має нескінченну довжину [2].

Довжина лінії з номером n рівна $(4/3)^n$–1. Тому граничної лінії нічого не залишається, крім як бути нескінченно довгої.

3. Сніжинка Коха обмежує кінцеву площу. І це при тому її периметр нескінченний. Ця властивість може здатися парадоксальним, але воно очевидно — сніжинка повністю міститься в коло, тому її площа свідомо обмежена.

4.Фрактальна размірність [2,3] дорівнює D=log4/log3 = $\log_{34}$ ≈ 1,261859... , одержано з формули:

$$D = log_{1/\delta} N \quad (1)$$

, де N –число пересічний квадратів, показане на рис. 2,

δ - розмір квадратів.

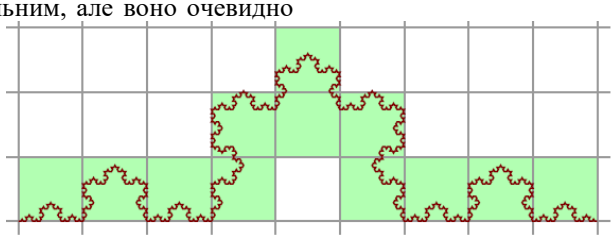

Рисунок 2. Визначення розмірності Коха через квадрат, у який вона вписана.

Існує безліч алгоритмів для побудови кривої сніжинки Коха, наприклад, у літературі [2-4]. Значною мірою ці алгоритми можна розділити на два типи: рекурсивний алгоритм і *L*-система з одним правилом. Було показано [2-4], що алгоритм на *L*-системі вимагає менше операцій.

Алгоритм побудови сніжинки Коха на базі *L*-системи:

Крок 1. Вихідний відрізок прямої довжини L (рис. 1 частина 1) ділиться на 3 рівних відрізка довжини $L/3$, і середній з них "ламаємо" – проводимо заміну на дві сторони рівностороннього трикутника з довжиною сторони $L/3$ (рис. 1 частина 2). Нова довжина $4L/3$, отриманої кривої лінії.

Крок 2. Крок 1 необхідно зробити для кожної рівної сторони замкненої фігури (мал. 3 частина 1).

Крок 3. Кожний прямий відрізок, після кроку 1 і 2, знову “ламаємо”, згідно, кроку 1. Одержуючи при цьому вужі 16 відрізків довжиною $L/9$ (рис. 1 частина 3 і рис. 3 частина 2). При цьому довжина буде рівна $(4/3)^2L$.

Нижче представлена сформовані сніжинки Коха за алгоритмом на базі *L*-системи з кількостью ітерацій n від 1 до 8.

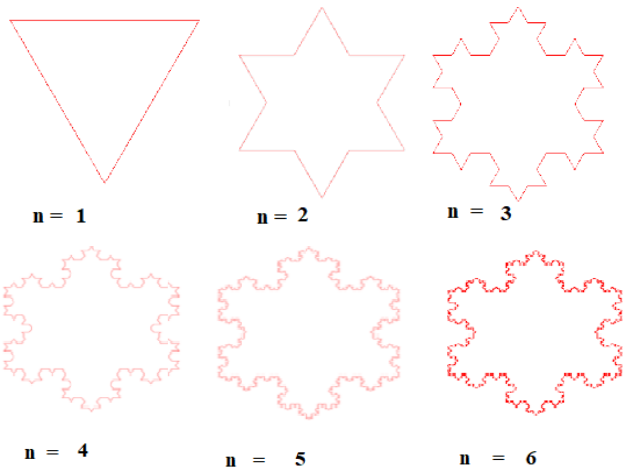

Рисунок 3. Формування сніжинки Коха програмно за алгоритмом на базі L-системи

Авторами запропонована модифікація алгоритма формування фрактала сніжинки Коха на базі *L*-системи, яка проводить операції тільки на верхній половині сніжинки, а іншу половину получаємо, формуя протилежні координати верхної половині сніжинки (рис. 4, n=3). Наприклад, за ітерацією n=3 формуємо верхню половину сніжинки, а саме координати (0,3), (2,4), (4,5), (6,6), (8,5), (10,4), (12,4), (12,1) і інши. А нижню половину сніжинки получаємо зміною координати осі У на протилежну, а саме (0,-3), (2,-4), (4,-5), (6,-6), (8,-5), (10,-4), (12,-4), (12,-1) і інши.

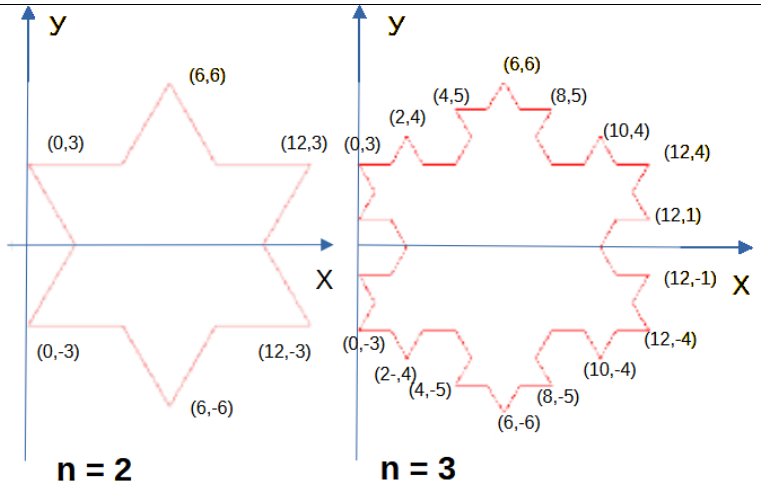

Рисунок 4. Формування сніжинки Коха за модифікованим алгоритмом на базі L-системи

Даний модифікація алгоритма починається тільки з ітерації n=3 для побудови фрактала сніжинки.

Модифікований алгоритм формування сніжинки Коха на базі *L*-системи будується з таких кроків:

1) До кроку з ітерацією n =3 – застосовуємо стандартний алгоритм на базі *L*-системи.

2) З кроку ітерації n=3 проводимо стандартний алгоритм на базі *L*-системи з поділяння кожного прямого відрузку на 3 рівної частини **тільки для верхної половини фігури** (рис. 4, n=3).

3) Після формування нових координат верхньої половини фігури другу - нижчу половину получаємо зміною координат точок верхньої половину на протилежні.

Як видно із алгоритму загальна кількість операцій буде наближатися до зменьшенняу майже 2 рази порівняно зі стандартним алгоритмом формування сніжинки Коха на базі *L*-системи при наближенні значення кількості ітерацій $n \to \infty$.

Нижче на рис. 5 показана залежність кількості часу виконання модифікованного алгоритма формування сніжинки Коха на базі *L*-системи (епюра 2) та стандартного алгоритма формування сніжинки Коха на базі *L*-системи (епюра 1) в залежності від кількості ітерацій.

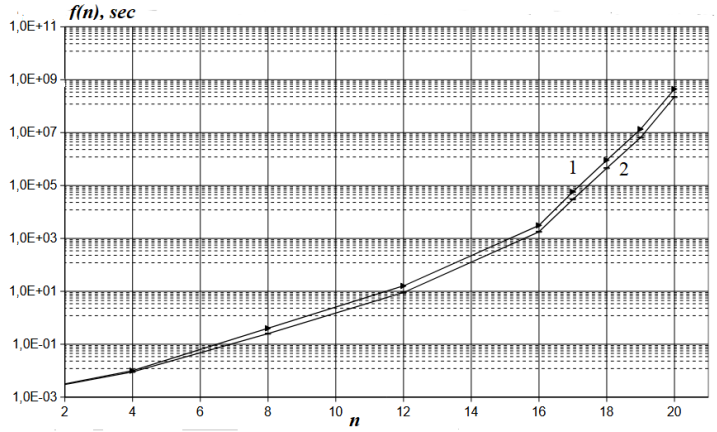

Рисунок 5. Залежність кількості часу формування фрактала сніжинки Коха в залежності від алгоритму та кількості ітерацій

Як помітно з рисунку 5 практична програмна реалізація на мові Python, з використованням ПК на базі Intel(R) Core(TM) i7-4700MQ CPU @2.40GHz та 16 Гбайт пам'яті, практично підтвердило попередні заключення, що модифікований алгоритм формування сніжинки Коха на базі *L*-системи зменшує необхідну кількість операцій майже у 2 раза порівняно зі стандартним алгоритмом.

Висновок

Представлений модифікований алгоритм формування сніжинки Коха на базі *L*-системи дозволив зменшити загальну кількість операцій майже у 2 рази порівняно зі стандратним алгоритм формування сніжинки Коха на базі *L*-системи.

Практична реалізація модифікованого алгоритма формування сніжинки Коха на базі *L*-системи дозволяє застосовувати її у комп'ютерної графіки: генерації 3D світів, візуалізації різних об'єктів та інше.

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ПРАКТИЧНІ РЕАЛІЗАЦІЇ СТВОРЕННЯ 3D СВІТІВ ЗА ДОПОМОГОЮ ФРАКТАЛЬНОЇ ГЕНЕРАЦІЇ

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PRACTICAL IMPLEMENTATION OF CREATING 3D WORLDS USING FRACTAL GENERATION

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Анотація

Запропоновано практичні реалізації генерування 3D світів на базі алгоритмів генерування шума. Показано як параметри генерування 3D світів впливають на будуємих ландщафт світу.

Abstract

Practical implementations of 3D world generation based on noise generation algorithms are proposed. It is shown how the parameters of 3D world generation affect the constructed world landscapes.

Ключові слова: Фрактал, фрактальна генерація, фрактальний шум, простий шум, генерація біомів, генерація висот, параметри впливу на генерацію 3D світів.

Keywords: Fractal, fractal generation, fractal noise, simple noise, biome generation, elevation generation, parameters affecting the generation of 3D worlds.

Постановка завдання та дослідження

Фрактальна генерація — це один із найпотужніших підходів до створення віртуальних світів, який дозволяє за допомогою математичних алгоритмів моделювати складні та природні за виглядом структури.

В основі методу лежить ідея самоподібності, притаманна багатьом об'єктам у природі: гори, хмари, річкові системи, узбережжя — усі вони мають схожі риси на різних масштабах. Фрактальна генерація імітує цю природну багатошаровість за допомогою спеціальних типів "шуму" — плавних псевдовипадкових змін значень.

Головна перевага фрактальної генерації в тому, що вона дозволяє отримувати надзвичайно складні й реалістичні ландшафти без необхідності вручну моделювати кожну деталь. Завдяки цьому підходу можливо створювати величезні, відкриті світи, які при цьому залишаються унікальними та природними.

Основні методи фрактальної генерації:

- Шум Перліна (Perlin Noise): Класичний алгоритм створення плавного псевдовипадкового шуму, який ідеально підходить для генерації контурів рельєфу — гірських хребтів, долин, пагорбів.
- Фрактальний шум (Fractal Noise): Техніка комбінування кількох шарів шуму Перліна з різною амплітудою та частотою (так звані "октави"), що дозволяє отримати ще складніші й реалістичніші текстури. Завдяки фрактальному шуму можливо зімітувати багатошарову структуру природи,

наприклад великі гори, всередині яких є дрібніші деталі.

- Простий шум (Simplex Noise): Покращена версія шуму Перліна, оптимізована для роботи в тривимірному просторі (3D). Він обчислюється швидше, краще масштабується і менше спотворюється на великих ділянках, що робить його популярним для сучасних ігор і симуляцій.

У сучасній ігровій індустрії створення великих ігрових світів вручну стало б надзвичайно трудомістким і дорогим процесом. Тому фрактальна генерація стала критично важливою технологією для:

- Нескінченного процедурного контенту: Ігри як *Minecraft*, *No Man's Sky*, *Terraria* використовують фрактальні алгоритми для створення унікальних світів, де кожна гора, річка чи печера формується процедурно.
- Оптимізації ресурсів: Завдяки процедурній генерації розробникам не потрібно зберігати наперед згенеровані карти — світ створюється "на льоту", економлячи пам'ять та обчислювальні ресурси.
- Різноманіття і реалістичність: Ландшафти, створені фрактальним шумом, виглядають природно та унікально навіть без ручного втручання художників.
- Розширення творчих можливостей: Процедурна генерація дає змогу гравцям і розробникам вивчати нові світи кожного разу, забезпечуючи величезну реіграбельність.

У данної статті розглянемо практичні методи генерації ландшафтів

Генерування Шума

Одним із популярних методів початку створення 3D-карт є застосування шумових функцій із обмеженою частотною смугою, таких як шум Perlin (1983 р.) або Simplex (2001р.) [1,2]. На сучасному етапі застосовують більш ефективний алгоритм генерування шуму - (Open Simplex Noise – 2014р.).

За алгоритмом Simplex (Open Simplex Noise – 2014р.) вхідні координати змінюються за формулою:

$$\begin{aligned} x' &= x + (x + y + z) * F \\ y' &= y + (x + y + z) * F \\ z' &= z + (x + y + z) * F \\ F &= (\sqrt{n+1} - 1)/n \end{aligned} \quad (1)$$

Знайдені координати вказують в яку комірку одиночної соти гіперкуба потрапляє вхідна точка $((x_b' = floor(x'), y_b' = floor(y'), z_b' = floor(z'))$ і її внутрішні координати $(xi' = x' - x_b', yi' = y' - y_b', zi' = z' - z_b')$.

Потім проводиться поділ на сімпелкси за допомогою сортування за спаданням внутрішніх координат, та визначення якій ортосхемі Шлефлі симплекса належить точка. Результуючий симплекс складається з вершин , що відповідають впорядкованному обходу від координат (0,0,0) до (1,1,1) при цьому можливо n! варіантів за одної перестановці координат.

Кожна вершина симплкса додається до координати відхиленого гіперкуба та хешується у псевдовипадковий вектор градієнта.

$$\begin{aligned} x &= x' + (x' + y' + z') * G \\ y &= y' + (x' + y' + z') * G \\ z &= z' + (x' + y' + z') * G \\ G &= (1/\sqrt{n+1} - 1)/n \end{aligned} \quad (2)$$

Дані координати віднімаються від вхідних координат, щоб отримати отримати невідхилений вектор переміщення. Це дозволяє порахувати екстраполярне значення градієнту за скалярним добутком та визначити d^2- квадрат відстанні до точки.

Потім внесок кожної вершини знаходимо за формулою:

$$(\max(0, r^2 - d^2))^4 * (\Delta x, \Delta y, \Delta z \cdot grad\ x, grad\ y, grad\ z) \quad (3)$$

r^2 - обирають рівним 0,5, що забезпечує відсутність розривів або 0,6 для покращення зовнішнього вигляду, коли невиликі розриві не будуть помітни.

Нижче наведемо приклад практичної реалізації на програмній мові python з використанням бібліотеки opennoise або noise, у якій реалізован віще означений алгоритм Simplex.

```
for (int row = 0; row < height; row++) {
  for (int col  = 0; col  < width; col ++) {
    double nx = col/width - 0.5, nrow = row /height - 0.5;
      value[row][col] = noise(ncol, nrow);
  }
}
```

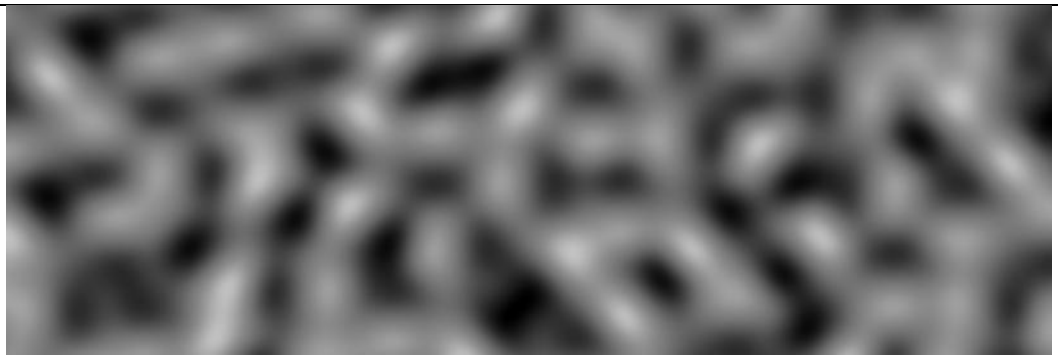

Рисунок 1. Приклад генерації шумів

Генерація висот

Шум сам по собі — це лише набір чисел. Подальше розвиток застосування шуму — використати шум для визначення висоти поверхні (так звану «карту висот»). Для цього потрібно шумові значення віднести до висот:

```
height[row][col] = noise(ncol, nrow);
```

У данному коді height є значеннями висот.

Результат виглядає, як безліч пагорбів:

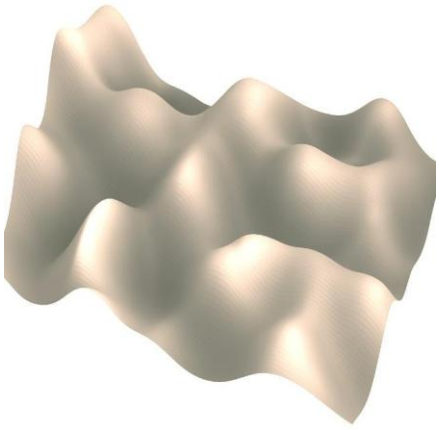

Рисунок 2. Генерація висот

Частота генерації

Шум можна генерувати на будь-якій частоті. Частота впливає на результат висот. Фактично, це просто масштабування шуму: збільшення або зменшення його розмірів.

Для простого визначення частоти генерації використуємо таку формулу:

```
height[row][col] = noise(4.44 * ncol, 4.44 * nrow);
```

Приклади генерації частоти:

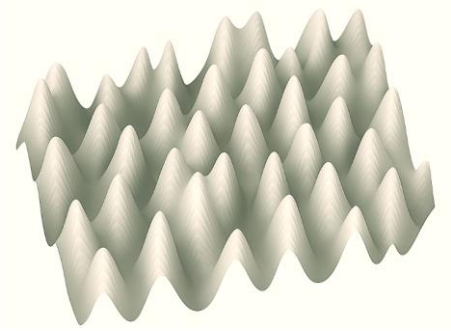

Рисунок 3. Приклад з частотою 4.44

Генерація кліматичних зон

Генерація біомів

Послідучий крок створити генерацію ландшафту з горами та долинами.

Для цього потрібно зробити так, щоб низькі висоти перетворювалися на воду:

```
function land(e) {
  if (e < waterlevel) return WATER;
  else return LAND;
}
```

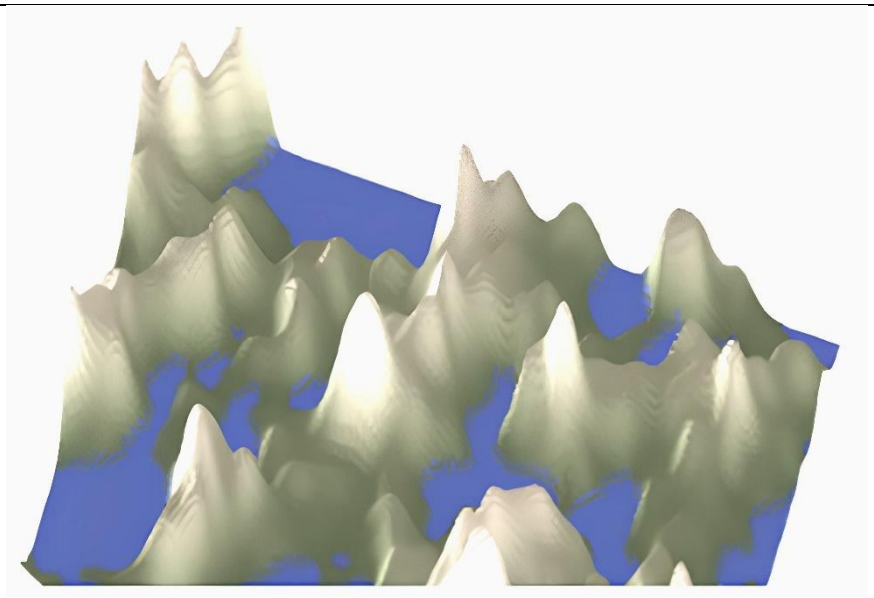

Рисунок 4. Приклад генерації з waterlevel = 0.50

Тепер в генерованому світі є вода але бажано додати різноманіття: траву, сніг і інше.

В фнкції, що наведена нижче, враховуємо вологість та висоту для створення біорізноманітного світу:

```
function determineLandscape(elevation, moisture) {
  if (elevation < 0.10) return OCEAN;
  if (elevation < 0.12) return BEACH;

  if (elevation > 0.80) {
     if (moisture < 0.10) return SCORCHED;
     if (moisture < 0.20) return BARE;
     if (moisture < 0.50) return TUNDRA;
     return SNOW;
  }

  if (elevation > 0.60) {
     if (moisture < 0.30) return TEMPERATE_DESERT;
     if (moisture < 0.60) return SHRUBLAND;
     return TAIGA;
  }

  if (elevation > 0.3) {
     if (moisture < 0.10) return TEMPERATE_DESERT;
     if (moisture < 0.50) return GRASSLAND;
     if (moisture < 0.80) return TEMPERATE_DECIDUOUS_FOREST;
     return TEMPERATE_RAIN_FOREST;
  }

  if (moisture < 0.10) return SUBTROPICAL_DESERT;
  if (moisture < 0.30) return GRASSLAND;
  if (moisture < 0.60) return TROPICAL_SEASONAL_FOREST;
  return TROPICAL_RAIN_FOREST;
}
```

В цьому коді створуємо іншу карта шуму для «вологості» і використовую її разом із висотою. В цієї функції row — це висота, а col — вологість. Завдякі данної функції отримуємо карту, яка виглядає набагато природніше: низькі висоти — це океани і пляжі, високі — скелі та сніг, а між ними — різні біоми.

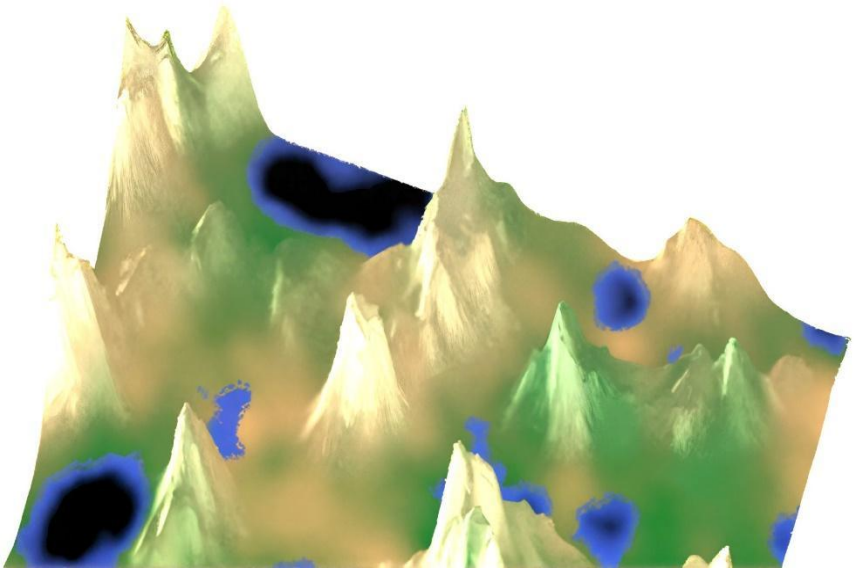

Рисунок 5. Генерація біомів

Генерація островів

Не можна уявити генерацію реалістичного світу без додавання островів. Один із простих способів це реалізувати — спочатку згенерувати карту, наприклад, як на рис. 2.2, а потім змінити її форму.

Змінити форму досить просто: потрібно примусово опустити прикордонні області в воду, а центральні частини, якщо вони у воді, навпаки, підняти вгору, щоб там була суша.

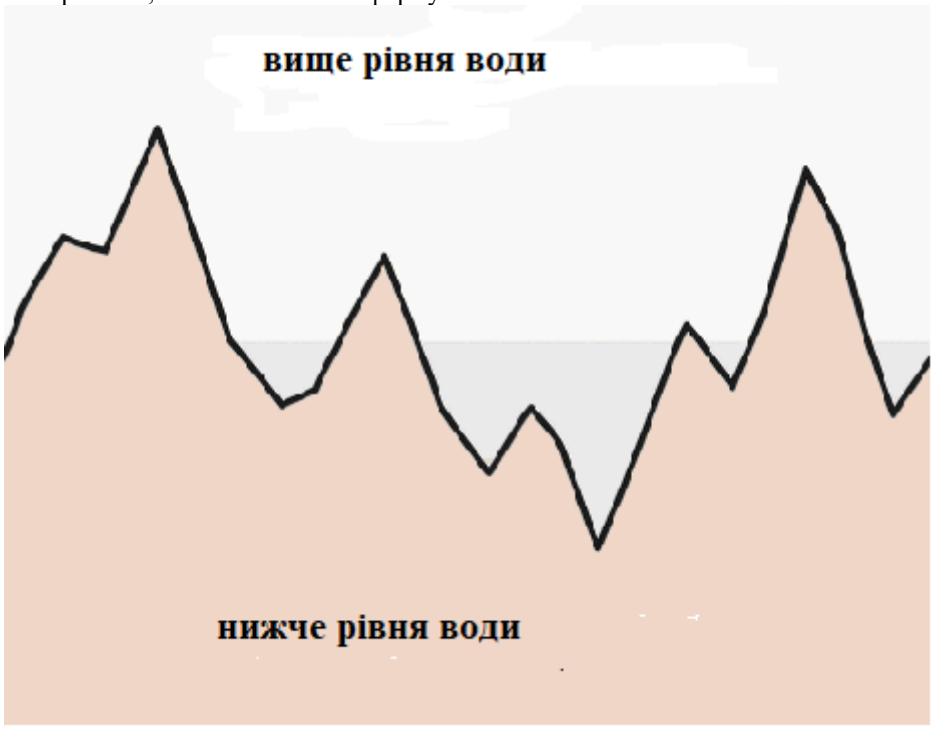

Рисунок 6. Схема рівня моря

Є два основних чинника при формуванні островів:

- Функція відстані: вона для кожної точки карти визначає відстань — від 0 у центрі карти до 1 на її межі.
- Функція формування (використовувано в розділі «Перерозподіл»): вона бере висоту як вхідні дані та видає нову висоту на виході.

```
double distanceFromCenter(int x, int y) {
  double centerX = mapWidth / 2.0;
  double centerY = mapHeight / 2.0;
  double dx = (x - centerX) / centerX;
  double dy = (y - centerY) / centerY;
  return sqrt(dx * dx + dy * dy);
}
double shapeFunction(double height, double distance) {
  return height - distance * distance;
}
```

У центрі карти, де відстань дорівнює 0, використовуємо функцію формування, яка завжди дає сушу. На краях карти, де відстань 1, функція формування завжди видає воду. Між цими крайніми значеннями формуємо у мапі мати як сушу, так і воду.

Для спрощення припустимо, що рівень води — це 0,5. Тобто, якщо висота ≥ 0,5 — це суша, а якщо менше 0,5 — вода.

Генерація лісів

Фрактальний шум також чудово підходить для розташування об’єктів, наприклад, дерев.

Для висоти обираємо шум із високою амплітудою та низькою частотою (так званий "червоний шум"). Для розміщення об’єктів більше підходить шум із високою амплітудою та високою частотою — це "зелений шум".

```
for (int row = 0; row < height; row++) {
for (int col = 0; col < width; col++) {
    double nx = col / (double)width - 0.5;
    double ny = row / (double)height - 0.5;
    greennoise[row][col] = noise(50 * nx, 50 * ny);
}
}
for (int rowc = 0; rowc < height; rowc++) {
for (int colc = 0; colc < width; colc++) {
  double max = 0;
       for (int dy = -R; dy <= R; dy++) {
           for (int dx = -R; dx <= R; dx++) {
                   int coln = dx + colc;
                        int rown = dy + rowc;
                   if (0 <= rown && rown < height && 0 <= coln && coln < width) {
                      double e = greennoise[rown][coln];
                          if (e > max)
                       {
                            max = e;
                            }
                       }
           }
       }
       if (greennoise[rowc][colc] == max)
       { }
}
}
```

Генеруємо карту шуму з великою деталізацією (висока частота), а потім у кожній околиці вибираю лише локальні максимуми шуму — саме там я розміщую об'єкти, наприклад, дерева. Також можу змінювати радіус R залежно від біому, щоб отримати різну густоту дерев у різних регіонах.

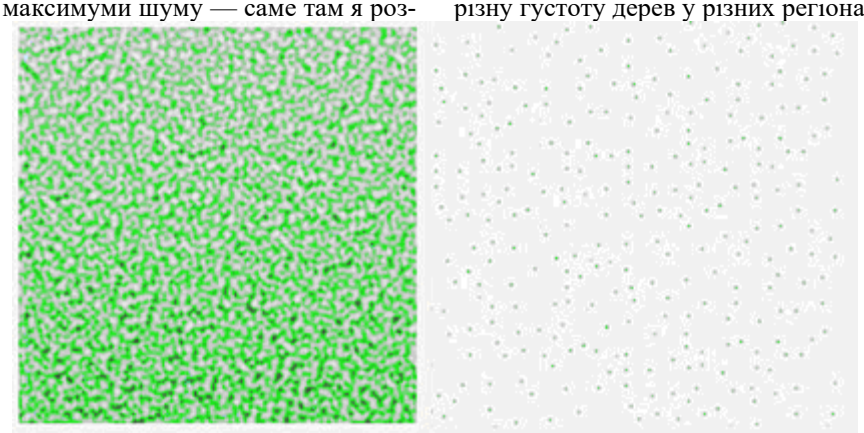

Рисунок 7. Генерація лісистості за R=0.4

ВИСНОВОК

У статті розглянути практичні моменти генерації 3D світів за допомогою фрактальної генерації. Вказані практичні приклади реалізацій коду для простого та швидкого генерування мапів 3D світів. Вказані основні коефіцієнти для генерування та вплив їх на побудову 3D світів.

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ЭВОЛЮЦИЯ ДИЗАЙНА И ФУНКЦИОНАЛЬНО-КОНСТРУКТИВНЫХ РЕШЕНИЙ ДЕТСКИХ КРОВАТОК ОТ ТРАДИЦИОННЫХ МОДЕЛЕЙ К МОДУЛЬНЫМ И ТРАНСФОРМИРУЕМЫМ СИСТЕМАМ

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EVOLUTION OF DESIGN AND FUNCTIONAL AND CONSTRUCTIVE SOLUTIONS OF CRIBS FROM TRADITIONAL MODELS TO MODULAR AND TRANSFORMABLE SYSTEMS

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Аннотация

Статья посвящена исследованию эволюции дизайна и функционально-конструктивных решений детских кроваток, с особым акцентом на переход от традиционных моделей к современным модульным и трансформируемым системам. В последние десятилетия наблюдается прогресс в разработке кроваток, что связано с изменениями в социальной среде, требованиями безопасности и развитием технологий. Традиционные кроватки постепенно уступают место инновационным моделям, которые предлагают гораздо больше возможностей для удобства и безопасности. Особое внимание уделено многофункциональным кроваткам, которые могут трансформироваться в различные формы, такие как кровать, диван или столик, что делает их более универсальными и экономичными для современных семей. Также рассматриваются вопросы безопасности, экологии и эргономики. Результаты исследования показывают, что современные решения позволяют не только повысить комфорт, но и увеличить срок службы мебели.

Abstract

The article is devoted to the study of the evolution of design and functional and constructive solutions of cribs, with a special emphasis on the transition from traditional models to modern modular and transformable systems. In recent decades, there has been progress in the development of cribs, which is associated with changes in the social environment, safety requirements and technology development. Traditional cribs are gradually giving way to innovative models that offer much more convenience and safety options. Special attention is paid to multifunctional cribs that can transform into various shapes, such as a bed, sofa or table, which makes them more versatile and economical for modern families. The issues of safety, ecology and ergonomics are also considered. The results of the study show that modern solutions can not only increase comfort, but also increase the service life of furniture.

Ключевые слова: детские кроватки, эволюция дизайна, трансформируемые кроватки, модульные системы, безопасность, эргономика, экологичность.

Keywords: crib, evolution of design, transformable cribs, modular systems, safety, ergonomics, environmental friendliness.

Актуальность исследования

Эволюция дизайна и функционально-конструктивных решений детских кроваток представляет собой важный аспект в области детской мебели, непосредственно влияющий на комфорт и безопасность детей. В последние десятилетия наблюдается прогресс в разработке и совершенствовании детских кроваток, что связано с изменениями в социальной среде, требованиями к безопасности, а также с развитием технологий производства. Традиционные модели, несмотря на свою долговечность и простоту, постепенно уступают место инновационным модульным и трансформируемым системам, которые предлагают гораздо больше возможностей для удобства и безопасности.

Современные детские кроватки становятся не только местом для сна, но и важным элементом интерьера, который должен сочетать эстетические качества, функциональность и адаптивность к растущим потребностям ребенка. Модульные и трансформируемые кроватки, предлагающие многофункциональные решения, такие как возможность трансформации в кресло или столик, становятся популярными среди родителей, ищущих удобство и долговечность в условиях ограниченного пространства. Это особенно актуально в условиях урбанизации и компактных жилищных пространств.

Кроме того, с развитием новых материалов и технологий производства, вопросы безопасности и экологичности становятся особенно важными. Сегодня мебель для детей должна не только соответствовать современным стандартам качества и безопасности, но и учитывать влияние на здоровье и развитие ребенка. Таким образом, исследование эволюции дизайна детских кроваток и их конструктивных решений является не только актуальным с научной точки зрения, но и важным для разработки оптимальных решений, соответствующих требованиям современности и потребностям семьи.

Цель исследования

Цель данного исследования – изучить эволюцию дизайна и функционально-конструктивных решений детских кроваток, а также выявить преимущества и недостатки традиционных и современных моделей.

Материалы и методы исследования

В работе использованы данные о традиционных и современных кроватках, собранные из открытых источников. Проанализированы основные этапы развития детской мебели, проведен сравнительный анализ конструктивных и функциональных особенностей традиционных и современных моделей, а также рассмотрены экологические и эргономические аспекты.

Результаты исследования

Историческое развитие кроваток для младенцев и детей отражает длительный путь человеческой заботы о безопасности и комфорте самых маленьких членов общества. Появление отдельных мест сна для детей связано с переходом от совместного сна с родителями к необходимости создания отдельной, защитной мебели. Первые приспособления для сна младенцев были крайне простыми – это могли быть плетеные корзины, выдолбленные коробы из дерева, а в ряде культур даже люльки-качалки, подвешенные на ветвях деревьев или на специализированных стойках, обеспечивающие защиту от опасностей на полу и дающие шанс матери заняться другими делами. Такие примитивные колыбели, по сути, представляли собой первые прототипы детских кроваток и были распространены в различных регионах мира на протяжении тысячелетий [2].

Основные этапы развития традиционных моделей детских кроваток можно выделить через призму изменений в материалах, формах и функциональных особенностях. Переход от простых и примитивных конструкций к более сложным и безопасным моделям, в свою очередь, отражает требования времени и развитие технологий. Ниже представлена таблица 1, которая детализирует ключевые исторические этапы и основные характеристики традиционных моделей детских кроваток.

Таблица 1

Основные исторические этапы развития традиционных моделей детских кроваток

Период	Основные формы и материалы	Ключевые особенности
Древнее время – Средние века	Плетёные корзины, деревянные углубления, простые люльки	Простота, переносимость, базовая защита
XV–XVIII вв.	Колыбели из дерева с декоративной резьбой	Повышенная эстетика, качающиеся механизмы
XIX в.	Решётчатые кроватки с регулируемым дном	Повышенная безопасность, стандартизация
Начало XX в.	Металлические и комбинированные модели	Новые материалы, улучшенная функциональность

Таким образом, традиционные модели детских кроваток прошли путь от простейших приспособлений до стандартизированных деревянных и металлических конструкций. Они отражают изменение подходов к заботе о младенцах, где главными аспектами стали безопасность, гигиена и удобство для родителей и детей.

Появление модульных и трансформируемых кроваток связано с развитием потребностей современных семей в функциональной и адаптивной мебели, способной работать не только как спальное место, но и как часть комплексного решения для детской комнаты. В отличие от традиционных кроваток, которые предназначены исключительно для сна ребёнка в первые месяцы жизни, трансформируемые модели интегрируют в себя несколько функций и могут изменять форму и назначение по мере роста ребёнка, обеспечивая долговечность и экономическую эффективность. На английском языке такие кроватки часто называют «convertible cribs» или «evolutive cribs» – то есть кровати, которые «растут» вместе с ребёнком за счёт смены конфигураций и уровней использования [4].

На рисунке ниже представлены примеры современных трансформируемых детских кроваток, которые могут изменять конфигурацию по мере роста ребёнка.

Рис. Примеры современных трансформируемых детских кроваток [1]

Ключевой характеристикой модульных и трансформируемых кроваток является их многофункциональность: за счёт отдельных модулей и сменных элементов такие конструкции могут выполнять функции не только спального места, но и игровой зоны, комода для хранения вещей, пеленального столика или даже небольшого стола и стульчика. Часто в одну систему входят базовая кроватка, дополнительные ящики, выдвижные модули и элементы для трансформации.

По мере роста ребёнка трансформируемые кроватки изменяют своё назначение. Например, базовая кроватка для новорождённого может быть преобразована в кроватку для малыша старшего возраста, затем – в детскую кровать с бортиками, а затем – в полноценную подростковую кровать без боковых стенок – этот процесс возможен за счёт смены парных деталей и регулировки высоты ложа. Аналогичные модели представлены на рынке как 3-в-1, 4-в-1, 8-в-1 кроватки, где каждая цифра указывает на количество основных конфигураций, доступных в одной конструкции [5].

Современные трансформируемые кроватки также отвечают требованиям безопасности и удобства: регулируемые по высоте матрасные основания позволяют адаптировать поверхность сна под возраст ребёнка, а наличие защитных бортиков и дополнительных упоров снижает риск травматизма. Многие модели обеспечивают экономию пространства и включают зоны хранения, что особенно актуально для небольших квартир и ограниченных площадей детской комнаты.

Ниже представлена таблица 2, обобщающая основные типы трансформируемых кроваток, которые сегодня доступны на рынке и устойчиво используются родителями благодаря своим функциональным возможностям.

Таблица 2

Основные типы модульных и трансформируемых детских кроваток

Тип кроватки	Основные функции	Особенности конструктивных решений
3-в-1 трансформер	Переход из кроватки → детская кровать → «диван» для отдыха	Регулируемое основание, сменные бортики
4-в-1 трансформер	Кровать новорождённого → детская кровать → кровать для подростка → зона отдыха или диван	Повышенная адаптация под разный возраст
8-в-1 трансформер и более	Вариативные конфигурации от люльки/колыбели → стандартная кроватка → подростковая кровать → дополнительный спальный модуль или игровая зона	Максимальная универсальность и срок эксплуатации
Модульные системы с комодом / хранением	Сочетают кроватку и модули хранения (ящики, комоды, пеленальные столы), часто объединённые в единую конструкцию	Интегрированные зоны хранения, оптимизация пространства комнаты

Как видно из таблицы 2, трансформируемые кроватки отличаются от стандартных решений наличием сменных элементов и возможностью адаптации к разным стадиям развития ребёнка, что делает их более выгодными и практичными для семей, стремящихся к рациональному использованию пространства и ресурсов.

Дизайн современных детских кроваток ориентирован на сочетание эстетики, функциональности и строго регламентированной безопасности, что отражает требования последних десятилетий к мебели для самых маленьких. Современные модели разрабатываются с учётом потребностей ребёнка на различных этапах его развития, а также с учётом удобства родителей. Это выражается в учёте антропометрии детей, эргономики взаимодействия с кроваткой, выборе материалов с минимальным риском токсичности и продуманных конструктивных решениях, позволяющих обеспечить безопасное и комфортное пространство для сна и отдыха ребёнка. Эксперты по безопасности подчёркивают, что стабильность конструкции, отсутствие острых углов, плавные поверхности и качественные поверхности отделки являются обязательными элементами эргономичного дизайна детской кроватки [6].

Одним из ключевых элементов эргономики детской кроватки является регулируемая по высоте поверхность для матраса. Такая конструктивная возможность позволяет адаптировать кроватку под рост и функциональные потребности ребёнка: на первых месяцах жизни удобнее использовать верхние положения, а по мере роста малыша матрас опускается, обеспечивая безопасность и предотвращая возможность ребёнка перелезть через бортики. Регулируемая высота – стандартная функция в современных кроватках и считается одним из основных факторов продуманной конструкции.

К эргономическим аспектам современного дизайна также относятся продуманные размеры и формы боковых ограждений, которые должны препятствовать травмам и защемлению частей тела, а также обеспечивать необходимую вентиляцию пространства для сна. Согласно европейским стандартам, например NF EN 716, размер между планками (бортиками) должен быть оптимальным – не настолько широким, чтобы возникал риск втягивания конечностей, и не настолько узким, чтобы нарушалась вентиляция воздуха [3].

Используемые материалы влияют как на безопасность, так и на визуальное восприятие кроватки. Поверхности должны быть выполнены из натуральных и сертифицированных материалов: массив дерева, безопасные водорастворимые лаки и краски, не содержащие летучих органических соединений, – эти решения отвечают современным требованиям экологичности и минимального воздействия на здоровье ребёнка. Современный дизайн кроваток учитывает также тенденции экологического подхода (эко-дизайн), где светлые натуральные оттенки, текстуры дерева и спокойная цветовая палитра создают атмосферу уюта и гармонии в детской комнате.

Современные кроватки также часто включают дополнительные функциональные элементы, такие как встроенные ящики для хранения постельного белья или съёмные панели, позволяющие адаптировать пространство под конкретные задачи, например, облегчение доступа к ребёнку во время ночных подъёмов или удобное размещение аксессуаров. Эти элементы усиливают эргономику изделия и повышают комфорт использования для всей семьи.

Помимо этого, эстетический дизайн кроваток отражает современные тенденции интерьера: размеры, формы и цветовые решения подбираются таким образом, чтобы кроватка гармонировала с общей стилистикой детской комнаты, не была чрезмерно яркой или агрессивной, но в то же время оставалась функционально удобной для ежедневного использования.

Сравнительный анализ традиционных и современных моделей детских кроваток позволяет выявить ключевые различия и преимущества каждого типа мебели, ориентированных на обеспечение безопасности, функциональности, экономичности и удобства использования.

Ниже представлена таблица 3, суммирующая ключевые различия между традиционными и трансформируемыми (современными) кроватками.

Таблица 3

Сравнение традиционных и современных трансформируемых кроваток

Параметр	Традиционные кроватки	Современные трансформируемые кроватки
Срок эксплуатации	Ограничен периодом младенчества (обычно до ~2-3 лет)	Может служить от младенчества до дошкольного / школьного возраста
Функциональность	Базовая (сон ребёнка)	Расширенная (сон, хранения, трансформация в другие виды спальных мест)
Регулируемая высота матраса	Часто отсутствует или ограничена	Обычно присутствует, несколько уровней регулировки
Экономическая ценность	Низкая – требуется замена по мере роста ребёнка	Высокая – одна кроватка заменяет несколько изделий через годы
Комплектация и аксессуары	Минимальный набор	Часто включает дополнительные модули хранения и трансформации
Соответствие современным требованиям безопасности	Должны соответствовать, но могут устареть со временем	Проектируются с учётом последних стандартов и рекомендаций по безопасности

Несмотря на очевидные преимущества трансформируемых кроваток, традиционные модели сохраняют свою актуальность за счёт более низкой первоначальной стоимости и классического дизайна, который может эстетически соответствовать интерьеру. Кроме того, для некоторых семей, особенно с ограниченным бюджетом или если кроватка предназначена только на первые несколько месяцев жизни ребёнка, традиционная кроватка остаётся практичным решением.

Сравнение традиционных и современных моделей показывает, что каждый тип имеет свои сильные и слабые стороны. Выбор зависит от индивидуальных потребностей семьи, планируемого срока использования мебели, доступного бюджета и предпочтений в функциональности и дизайне. При этом современные трансформируемые кроватки благодаря своей адаптивности и многофункциональности отвечают растущим требованиям современных семей, стремящихся к максимально рациональному использованию пространства и ресурсов.

Перспективы развития дизайна и функционально-конструктивных решений детских кроваток в будущем будут ориентированы на повышение безопасности, удобства и долговечности. Важными направлениями станут улучшение эргономики, интеграция умных технологий, таких как сенсоры для мониторинга сна и здоровья ребёнка, а также использование экологичных материалов. Также ожидается дальнейшее совершенствование трансформируемых и модульных решений, позволяющих кроваткам адаптироваться к изменениям в потребностях семьи и возрасту ребёнка, обеспечивая многофункциональность и экономию пространства. В результате такие кроватки станут более универсальными и технологичными, предлагая оптимальное сочетание практичности и безопасности.

Выводы

Исследование эволюции дизайна и функционально-конструктивных решений детских кроваток показало, что в последние десятилетия произошли значительные изменения в подходах к их разработке. Традиционные кроватки, несмотря на свою долговечность и проверенную временем простоту, постепенно уступают место более инновационным моделям, таким как модульные и трансформируемые кроватки. Современные решения предлагают множество преимуществ, включая многофункциональность, долгосрочное использование и возможность адаптации к различным возрастным этапам ребёнка, что делает их экономически выгодными и удобными для современных семей.

Ключевыми аспектами современного дизайна являются повышенные требования к безопасности, эргономике и экологичности материалов. Трансформируемые кроватки, которые могут изменять свою конфигурацию и выполнять функции не только спального места, но и зоны хранения или игрового пространства, становятся всё более популярными среди родителей, особенно в условиях ограниченного пространства в городских квартирах.

Таким образом, развитие детских кроваток в будущем будет ориентировано на ещё более высокую степень адаптивности, безопасности и интеграцию современных технологий. Эти изменения соответствуют потребностям современной семьи, стремящейся к удобству и практичности в использовании мебели для детей.

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